STUDIES ON WESTERN AUSTRALIAN PERMIAN BRACHIOPODS 11. NEW GENERA, SPECIES AND RECORDS

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ARCHBOLD, N. W., 1993:03:31. Studies on Western Australian Permian brachiopods 11. New genera, species and records. *Proceedings of the Royal Society of Victoria* 105 (1): 1–29. ISSN 0035-9211.

New genera, species and records of Permian Brachiopoda that are important in the biostratigraphy of the Western Australian Permian marine sequences are described and illustrated. New taxa described include *Gatia superba* gen. et sp. nov., *Heteralosia (Etheralosia)* subgen. nov. (type species *Strophalosia etheridgei* Prendergast, 1943), *Coolkilella* gen. nov. (type species *Cancrinella coolkilyaensis* Archbold, 1983), *Neochonetes (Sommeriella) nalbiaensis* sp. nov., *N. (S.) hardmani sp. nov., Costatumulus occidentalis* sp. nov., *Cartorhium imperfectum* sp. nov. and *Spirelytha kashirtsevi* sp. nov. A lectotype is designated for *Productus humboldtii* d'Orbigny, 1842, type species of *Waagenoconcha* Chao, 1927.

SINCE the publication of the first ten parts of this series of works on Western Australian Permian brachiopods, numerous additional specimens have been collected by various organisations or have been found in institutional collections. The present study brings together various specimens that add to new generic concepts, represent new species or new records of stratigraphical occurrences, or provide new morphological information.

The specimens described come from the Permian sequences of the Perth, Carnarvon, Canning and Bonaparte Gulf Basins of Western Australia. References to the Permian stratigraphy of these basins are given in previous parts of this series, and specific locality and stratigraphical data are given herein with the systematic descriptions. Each species is assigned to the Western Australian Permian brachiopod zonation recently proposed by me (Archbold in press).

All material described is deposited in the following institutions: the Australian Museum, Sydney (AMF); the Commonwealth Palaeontological Collections (CPC) of the Australian Geological Survey Organisation (AGSO), Canberra; the Geological Survey of Western Australia, Perth (GSWA F); the Department of Geology, University of Western Australia, Perth (UWA); the Western Australian Museum, Perth (WAM) and the Museum of Victoria, Melbourne (NMV).

All illustrated specimens of new species other than holotypes are paratypes.

SYSTEMATIC PALAEONTOLOGY

Phylum BRACHIOPODA
Order STROPHOMENIDA Öpik, 1934
Suborder ORTHOTETIDINA Waagen, 1884
Superfamily ORTHOTETACEA Waagen, 1884
Family DERBYIIDAE Stehli, 1954
Subfamily DERBYIINAE Stehli, 1954

Genus Derbyia Waagen, 1884

Type species. Derbyia regularis Waagen, 1884.

Derbyia hardmani Thomas, 1958a

Fig. 1A

Derbyia sp.—Thomas 1957: 181.—Thomas 1958b: 3.
Derbyia hardmani Thomas 1958a: 78, pl. 5, figs 5–9, pl. 18, fig. 6, pl. 9, fig. 2.—Thomas 1969: 221.—Archbold 1988a: 22.

Comments. This species has been recorded but never figured from the Upper Marine Beds of the Port Keats Group (Thomas 1957, 1958b; Archbold 1988a). The only available specimen (CPC 24511) comes from locality PK 4 (see map in Thomas 1957: 176), on the coast 13.5 km north of Cape Dombey, Port Keats area, Northern Territory. It is a large ventral valve (73 mm wide, 54+ mm length), essentially flat with a gently concave median portion and strongly convex posterior lateral flanks. Although it is preserved as a natural ferruginous cast, traces of fine costellae, some 10 to 11 per 5 mm at 3 to 4 cm from the umbo, are visible. Costellae in-

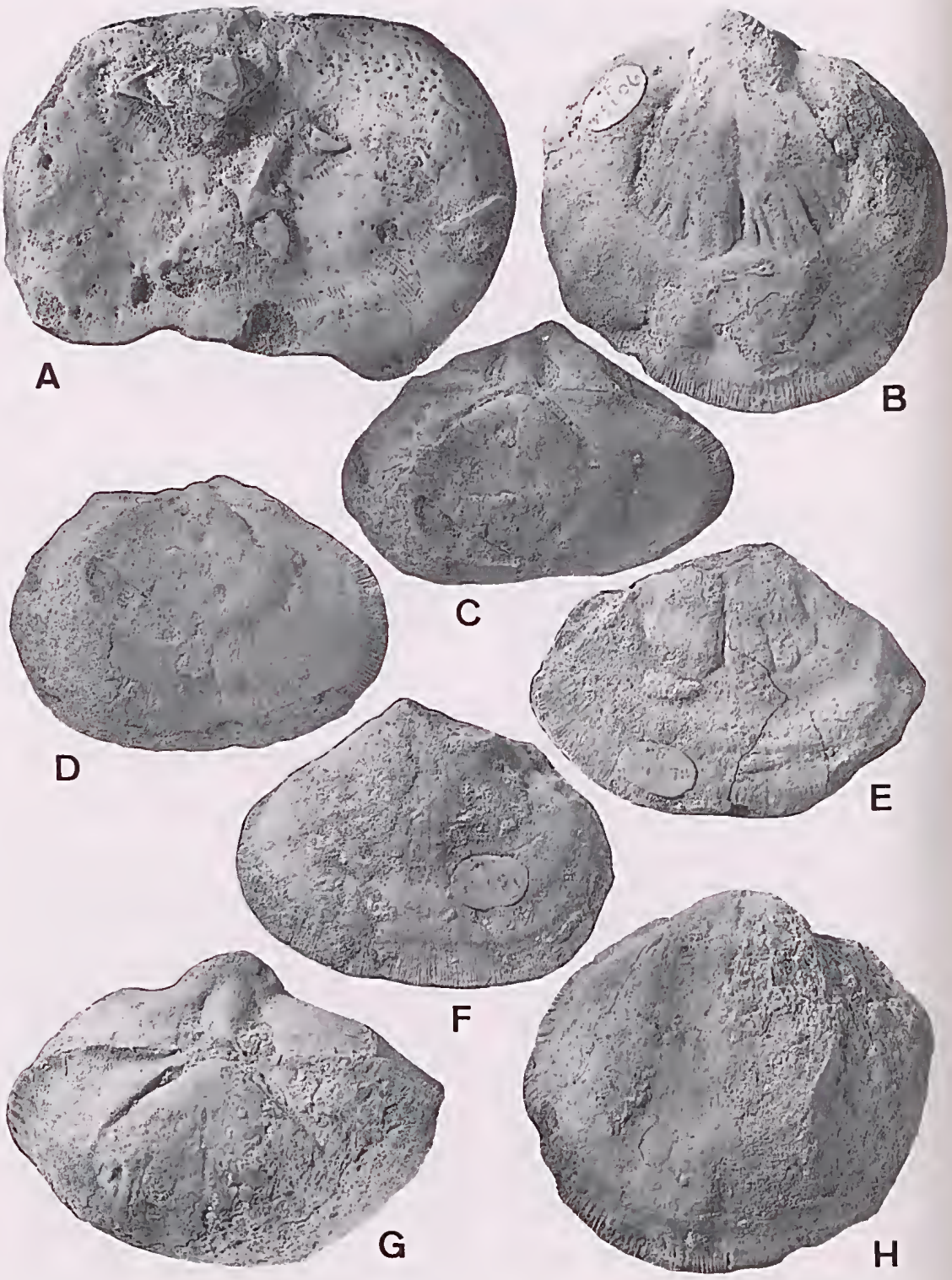
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Fig. 1. A, *Derbyia hardmani* Thomas, CPC 24511, natural cast of ventral valve, × 1. B–H, *Steptorhynchus luluigui* Hosking. B, G, H, AMF 45006, complete internal mould of shell in ventral, posterior and dorsal views, × 1. C, D, F, AMF 44980, internal mould of shell in posterodorsal, dorsal and ventral views, × 1. E, AMF 44974, internal mould of shell in ventral view, × 1.

crease by intercalation. The poorly preserved interarea is low (approximately 9 mm high), flat and apsacline.

Zone. Waagenoconcha imperfecta Zone. Dzhulfian.

Family STREPTORHYNCHIDAE Stehli, 1954

Genus **Streptorhynchus** King, 1850

Type species. Terebratulites pelargonatus Sehlotheim 1816.

Streptorhynchus luluigui Hosking, 1932

Figs 1B–H, 2A–C

Streptorhynchus luluigui.—Archbold 1988a: 24, fig. 2A–Q (with synonymy).

Comments. This species has been extensively described and figured from the Hardman Formation of the Canning Basin (Hosking 1932, Thomas 1958a), where it appears to be restricted to the Kirkby Range Member (Archbold 1988a). In the Bonaparte Gulf Basin sequence, *S. luluigui* is characteristic of Assemblage C of Thomas (1957, 1958b) and is apparently absent from Assemblage D (Archbold 1988a).

No specimens have been figured previously from the Upper Marine Beds of the Port Keats Group, Bonaparte Gulf Basin, despite a magnificent suite of material having been collected by H. O. Fletcher of the Australian Museum in 1952 from an ironstone ridge at the Port Keats Mission (locality 5 of Thomas 1957: 176). A number of these specimens are figured herein because they are of relatively large size and, being internal moulds, show the muscle scars and the degree to which the external ornament is visible on the mature shell interior. Ventral musculature can be deeply impressed, as noted by Thomas (1958a). The ventral muscle field is

Fig. 2. Streptorhynchus luluigui Hosking. A, B, AMF 44996, internal mould of shell in posterior and dorsal views, × 1.2 and × 1. C, AMF 44974, internal mould of shell in dorsal view, × 1.

weakly divided by a low median ridge (Fig. 1B, E) at full maturity.

Zone. Liveringia magnifica Zone. Late Midian or Early Djhulfian.

Order CHONETIDA Nalivkin, 1979
Suborder CHONETIDINA Muir-Wood, 1955
Superfamily ANOPLIACEA Muir-Wood, 1962
Family ANOPLIIDAE Muir-Wood, 1962

Genus **Gatia** gen. nov.

Etymology. For Dr G. A. Thomas, palaeontologist and stratigrapher.

Type species. Gatia superba sp. nov.

Diagnosis. Large, smooth anopliid-shaped shells, widest at hinge. Ventral interior with short median septum posteriorly and with parallel vascular trunks extending to valve anterior on either side of septum. Dorsal interior with short lateral septa extending to form rounded, club-shaped brachiophores. Short median septum arising anterior to shallow alveolus and separated from short central septum by narrow depressed region. Short accessory septa (or ridges) developed anterior to central septum, apparently by fusion of a row of papillae.

Discussion. The dorsal interior of *Gatia* gen. nov. resembles that of no other anopliid genus. The short accessory septa (or ridges) suggest an anopliid affinity but the central septum, anterior to the short median septum, recalls ontogenentic stages of rugosochonetids. Lateral septa also recall rugosochonetids. Nevertheless, the advanced brachial ridges of Permian rugosochonetids are absent. The subfamilial position of *Gatia* is left open; the genus would probably fit within the Anopliinae in the sense of Archbold (1980a) but it is not clear where it would be placed in the scheme proposed by Afanasyeva (1988).

Gatia superba sp. nov.

Fig. 3A–L

Tornquistia magna Archbold 1980a (*partim*): 186, pl. 25, figs 9, 13 (*non cet.*).

Holotype. An isolated dorsal valve (NMV P120329) from the Lyndon River, 9.20 km (5.75 miles) west-north-west of Round Hill Well, Mia Mia Station, Carnarvon Basin; originally mapped as Bulgadoo Shale, now Madeline Formation, lower member. This and all other specimens (below) were presented to the Department of Geology, University of Melbourne by the Bureau of Mineral Resources on 8 Feb. 1954.

Other material. Paratypes: NMV P120330, an isolated dorsal valve; NMV P120331–P120333, three conjoined shells; and NMV P120334–P120336, three isolated ventral valves. Forty-three additional specimens were available for study. All specimens are from the same collection as the holotype.

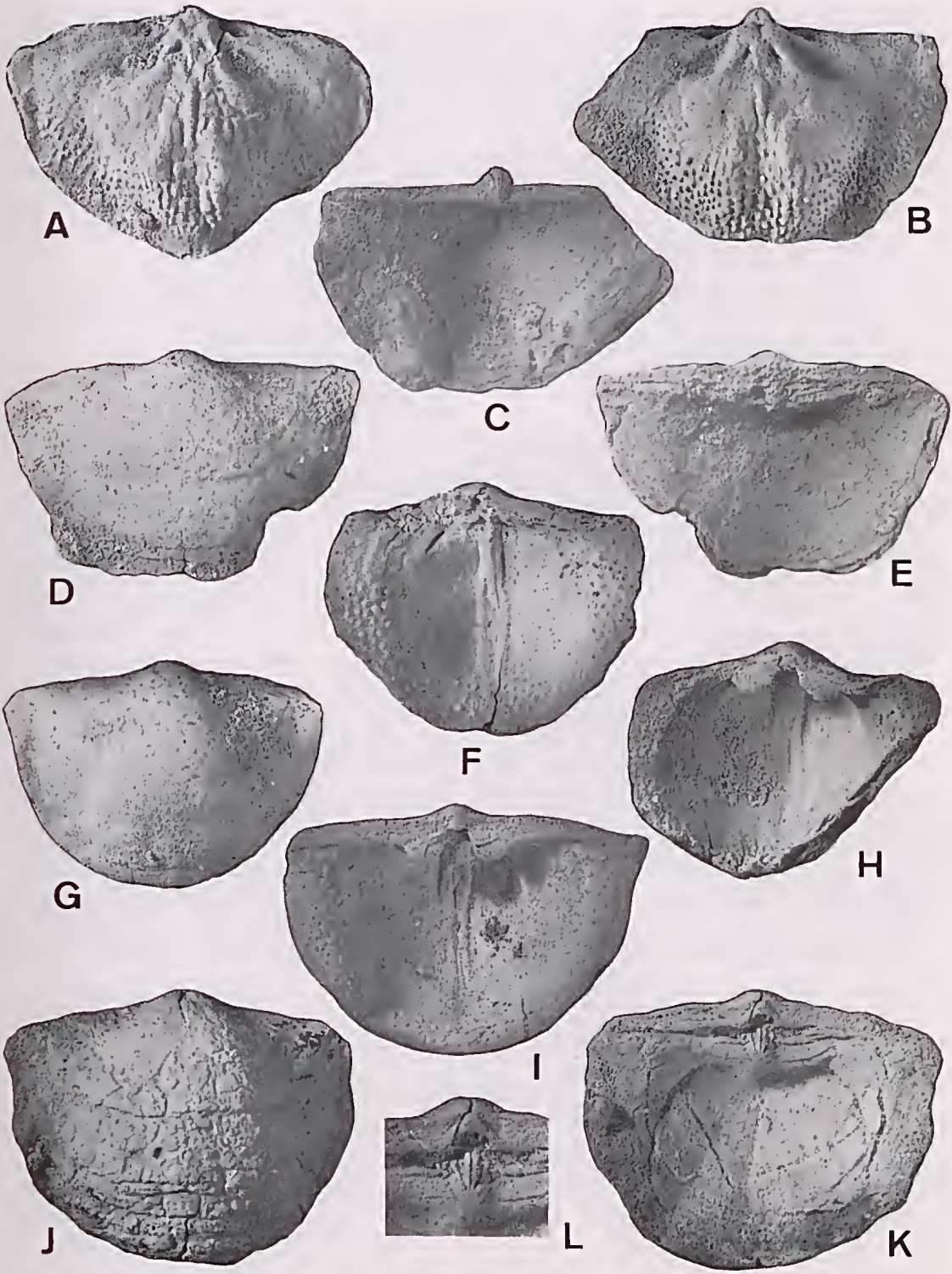
Size ranges. Maximum width 11.9–16.4 mm; ventral length 9.2–11.3 mm; dorsal length 7.5–10.2 mm.

Description. Large sized anopliid. Convexity of ventral valve pronounced with strongly inflated mesial portion in the form of a broad fold. Dorsal valve concave with marked median concavity corresponding with broad ventral fold. Greatest width of shell at hinge line. Exterior surface of shell smooth with few growth lines, except for anterior of mature valves where growth lines are more distinct and numerous. Ventral interarea prominent, about 1.5 times dorsal interarea height. Cardinal spines poorly preserved, widely spaced. Ventral umbo fine and rounded.

Ventral interior with prominent, large, strong teeth. Delthyrium distinct with thickening of shell beneath it. High, sharp median septum bisects delthyrium and extends short distance anteriorly on valve floor. Small, distinct pseudodeltidium in apex of delthyrium. Parallel vascular trunks arise adjacent to septum and extend anteriorly for most of valve length. Muscle scars weakly impressed. Anterior and lateral margins of valve interior finely papillose.

Cardinal process distinct, blunt; internal face weakly bilobed, exterior face quadrilobed. Distinct chilidium beneath exterior face of process. Valve interior with shallow alveolus at base of cardinal process. Short, broad median septum arises anterior to alveolus. Median septum truncated at anterior end by small depression, anterior to which arises a short central septum. Lateral septa short, broad and distinct, extending anteriorly to form rounded, club-shaped

Fig. 3. Gatia superba gen. et sp. nov. A, NMV P120330, isolated dorsal valve, interior view, × 3.5. B, C, NMV P120329, holotype, isolated dorsal valve, interior and exterior views, × 3.5. D, E, NMV P120331, shell in ventral and dorsal views, × 3.6. F, NMV P120334, isolated ventral valve, interior view, × 3.7. G, NMV P120332, shell in ventral view, × 3.6. H, NMV P120335, ventral valve interior view, × 3.6. I, NMV P12O336, ventral valve interior view, × 3.5. J–L, NMV P120333, shell in ventral and dorsal views, × 3.5, and umbonal region enlarged, × 5.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brachiophores. Socket plates stout, sockets large. Anterior of valve with rows of radiating papillae; adjacent and anterior to the central septum, two or more of these rows fuse to form rough, accessory septa (or ridges). Posterior margins of valve smooth.

Discussion. No other species is known with the combination of large size and the dorsal internal features of *Gatia superba*. Other Western Australian anopliids described by me (Archbold 1980a, 1990) exhibit incipient characters of this new form, such as the minute lateral and median (central) septa, but in dorsal structures those species do not closely resemble *Gatia superba*.

Two ventral valves from the lower member of the Madeline Formation were previously included by me in *Tornquistia magna* (Archbold 1980a, pl. 25, figs 9a, b, 13a–c). They are large valves that are morphologically similar to the present population. Hence *Tornquistia magna* is now considered to be restricted to the true Bulgadoo Shale.

Zone. Echinalosia prideri Zone. Early Baigendzhinian.

Superfamily CHONETACEA Bronn, 1862
Family RUGOSOCHONETIDAE Muir-Wood, 1962
Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus Neochonetes Muir-Wood, 1962
Subgenus Neochonetes (Sommeriella) Archbold, 1982

Type species. Chonetes prattii Davidson, 1859.

Neochonetes (Sommeriella) nalbiaensis sp. nov.

Fig. 4A–N

Neochonetes (Sommeria) tenuicapillatus Archbold 1981d (*partim*): 122, fig. 9X, Y (*non cet.*).

Holotype. A natural internal mould of a dorsal valve (GSWA F43854) from GSWA field locality 9568 (photo reference Kennedy Range Run 2 Photo 5022), north-west of Paddy's Outcamp and south-west of Middalya Homestead, Carnarvon Basin; Nalbia Sandstone. Collector Dr S. K. Skwarko, June 1985.

Other material. Paratypes: GSWA F43855–F43857, three external moulds of ventral valves; GSWA F43858–F43861, four internal moulds of ventral valves; GSWA F43862, an external mould of a dorsal valve; GSWA F43863–F43867, five internal moulds of dorsal valves. Same locality, horizon and collector as holotype.

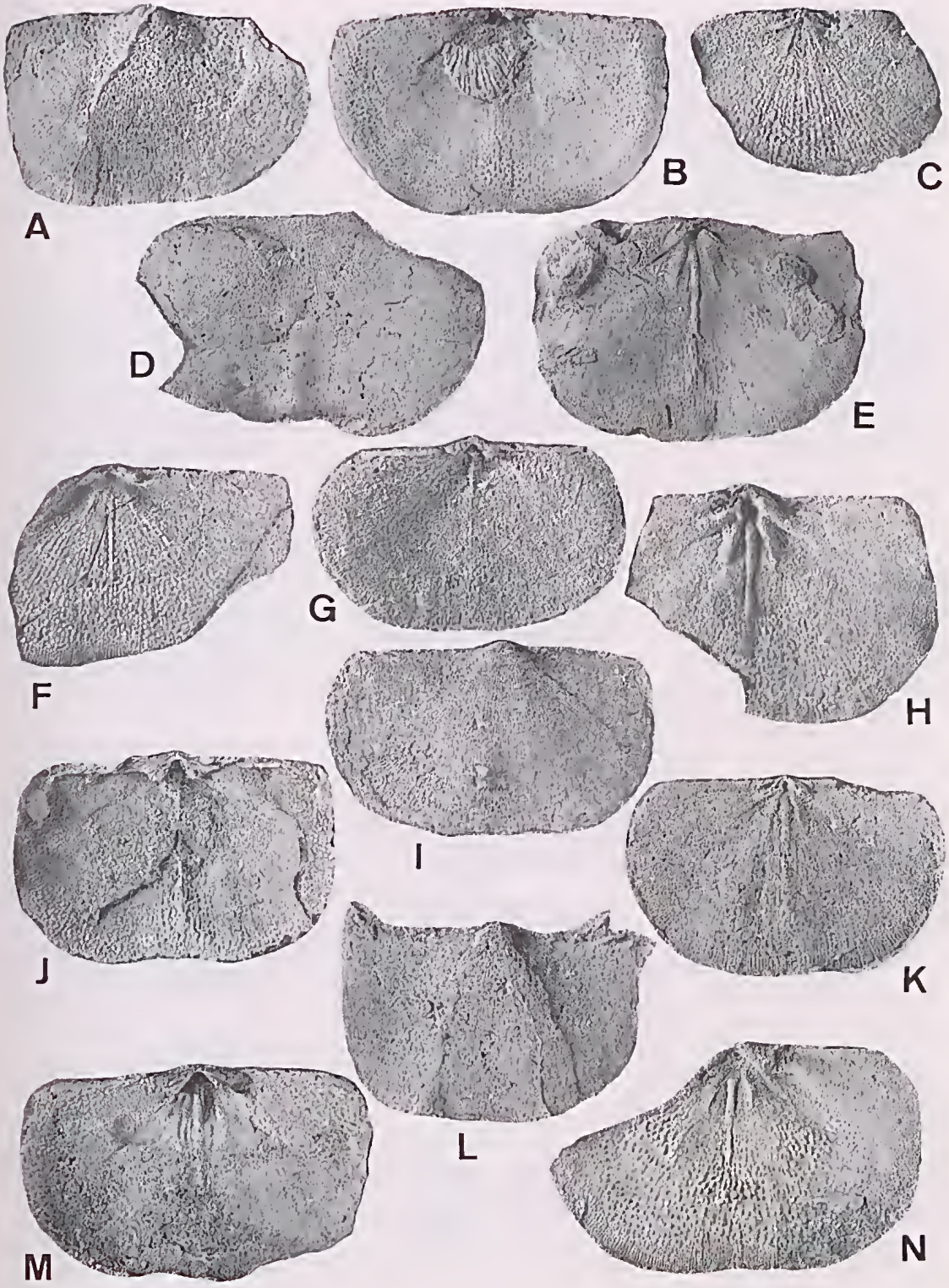
Size ranges. Maximum width 12.2+–28.3 mm; hinge width 15.5–26.9 mm; height of ventral valve 11.8–18.2 mm; height of dorsal valve 8.2–19.1 mm.

Description. Large *Neochonetes*. Convexity of ventral valve gentle with shallow sulcus arising close to umbo. Dorsal valve planar to gently concave with narrow, weakly developed fold developed anteriorly at maturity. Greatest width of shell at about mid-length or anterior to mid-length. Exterior surface of shell with weakly developed growth lines and fine capillae (about 4 per mm at 10 mm from umbo). Ventral interarea low, dorsal interarea very low. Cardinal spines project at variable angle (35° to 50°) on the one available specimen. Ventral umbo low, rounded.

Ventral interior with short, stout teeth. Delthyrium distinct, broad, relatively small. Median septum arises under delthyrium, extends anteriorly for over three-quarters of valve length. Muscle scars variably impressed; adductor scars usually indistinct, diductor scars relatively distinct. Vascular trunks weakly developed. Anterior and lateral margins of interior strongly papillose.

Cardinal process low, poorly known. Chilidium not known. Valve interior with prominent alveolus at base of process. Socket ridges prominent; sockets distinct, deep. Lateral septa and median septum distinct, arising anterior to alveolus. Median septum extends anteriorly from 50% to 60% of valve length. Brachial ridges indistinct; region of ridges relatively coarsely pa-

Fig. 4. Neochonetes nalbiaensis sp. nov. A, GSWA F43855, latex cast of ventral valve external mould, × 2.5. B, GSWA F43858, latex cast of dorsal valve internal mould, × 1.7. C, GSWA F43863, latex cast of dorsal valve internal mould, × 3.2. D, GSWA F43862, latex cast of dorsal valve external mould, × 2.3. E, GSWA F43854, holotype, latex cast of dorsal valve internal mould, × 1.6. F, GSWA F43864, latex cast of dorsal valve internal mould, × 2.7. G, GSWA F43859, latex cast of ventral valve internal mould, × 2.5. H, GSWA F43865, latex cast of dorsal valve internal mould, × 2.3. I, GSWA F43856, latex cast of ventral valve external mould, × 2.3. J, GSWA F43860, latex cast of ventral valve internal mould, × 1.7. K, GSWA F43866, latex cast of dorsal valve internal mould, × 2.2. L, GSWA F43857, latex cast of ventral valve external mould, × 2.3. M, GSWA F43861, latex cast of ventral valve internal mould, × 2.1. N, GSWA F43867, latex cast of dorsal valve internal mould, × 2.1.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pillose at maturity. Anterior of dorsal interior with radiating rows of fine papillae. Posterior margins of valve smooth.

Discussion. This distinctive species requires well preserved collections to permit identification. The low ventral convexity and relatively flat dorsal valve discriminate the species from the slightly older *N. (S.) tenuicapillatus* Archbold, 1981d from the Upper Baigendzhinian of the Carnarvon Basin. The younger *N. (S.) afanasyevae* Archbold, 1981d also is characterized by low ventral convexity but the sulcus is even weaker in that species, the shell outline is somewhat rounder and the internal dorsal septa are more blade-like.

One submature shell from the Nalbia Sandstone was previously included by me in *N. (S.) tenuicapillatus* (see synonymy) but falls within the concept of the new species.

Zone. Neochonetes (Sommeriella) sp. nov. B zone of Archbold (in press), herein renamed the *N.(S.) nalbiaensis* Zone. Early Kungurian.

Neochonetes (Sommeriella) hardmani sp. nov.

Fig. 5A–O

Neochonetes (Sommeria) sp. A.—Archbold 1981d (*partim*): 126, fig. 12 A, B (*non* 12C).

Holotype. An isolated dorsal valve (NMV P120350) from a bed 1.25 m thick at about 40 m below top of Mount Hardman; Cherrabun Member, Hardman Formation, Canning Basin (same level as AGSO locality KLB 11), collector Dr G. A. Thomas.

Other material. Paratypes: NMV P120337–P120343, seven isolated ventral valves; NMV P120344, a conjoined shell; NMV P120345–P120349, five isolated dorsal valves; same locality and collector as holotype.

Size ranges. Maximum width 11.8–15.1 mm; hinge width 11.1–14.3 mm; height of ventral valve 9.2–11.0 mm; height of dorsal valve 7.7–10.2 mm.

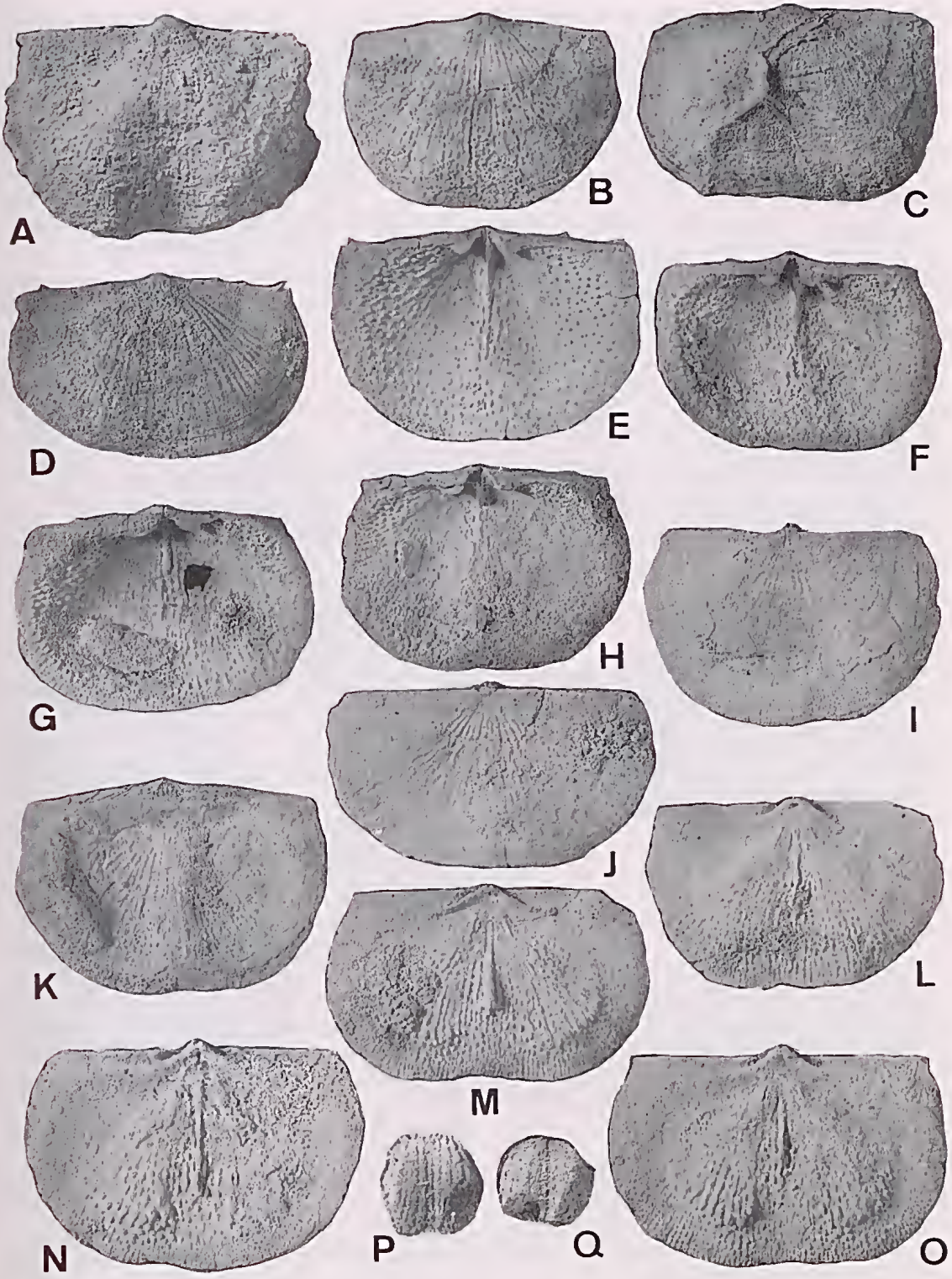
Description. Small *Neochonetes.* Convexity of ventral valve distinct with shallow sulcus arising close to umbo. Posterior lateral margins of valve clearly demarcated from remainder of valve. Dorsal valve planar with gently concave nepionic region. Dorsal fold obscure. Greatest width of shell usually at about 40% of shell length, rarely closer to mid-length. Exterior surface of shell with weakly developed growth lines and capillae (about 3 per mm at 5 mm from umbo). Ventral interarea low, dorsal interarea very low. Ventral umbo low, cardinal spines project at about 40° from posteror margin. Ventral teeth unthickened. Delthyrium distinct, broad. Median septum arises under delthyrium, extends anteriorly for 40% to 60% of shell length. Muscle scars usually weakly impressed. Parallel vascular trunks weakly to distinctly developed. Anterior and lateral margins of interior strongly papillose.

Cardinal process low, weakly bilobed on interior face, quadrilobed on exterior face. Chilidium not known. Prominent alveolus at base of process. Socket ridges stout, strong with deep slit-like sockets. Lateral septa present but not prominent. Median septum arises well anterior to the alveolus, blade-like and high anteriorly at maturity. Median septum extends anteriorly over 60% of valve length. Brachial ridges moderately distinct at maturity, developing and enlarging from radial rows of papillae. Anterior of dorsal interior with radiating rows of fine papillae. Posterior margins of valve interior smooth.

Discussion. Of all the Western Australian representatives of *Neochonetes (Sommeriella)*, only *N. (S.) hockingi* Archbold, 1991 resembles the present species in general shell dimensions. *N. (S.) hardmani* is readily distinguished from that species by its more prominent sulcus, demarcated posterior lateral margins, lower cardinal process and finer, more blade-like dorsal internal septa.

The large specimen of a ventral valve (CPC 1984; Archbold 1981, fig. 12C) is now excluded by me from *N. (S.) hardmani.* It apparently represents a larger, poorly known species that is probably allied to *Neochonetes (Sommeriella).*

Fig. 5. A–O, *Neochonetes (Sommeriella) hardmani* sp. nov. A, NMV P120337, ventral valve exterior view, × 3.2. B, K, NMV P120344, conjoined shell in ventral and dorsal views, × 3, × 3.2. C, NMV P120338, ventral valve exterior view, × 3.2. D, NMV P120339, ventral valve exterior view, × 3.2. E, NMV P120340, ventral valve interior view, × 3.2. F, NMV P120341, ventral valve interior view, × 3.2. G, NMV P120342, ventral valve interior view, × 3.2. H, NMV P120343, ventral valve interior view, × 3.2. I, NMV P120345, dorsal valve exterior view, × 3.2. J, NMV P120346, dorsal valve exterior view, × 3.2. L, NMV P120347, dorsal valve interior view, × 3.2. M, NMV P120348, dorsal valve interior view, × 3.2. N, NMV P120349, dorsal valve interior view, × 3.2. O, NMV P120350, holotype, dorsal valve interior view, × 3.2. P, Q, *Waagenites* sp., CPC 24512a, latex cast of ventral valve external mould, and CPC 24512b, ventral valve internal mould, × 3.5.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Neochonetes is not particularly common in Late Permian strata. Some species of this age show a trend towards weakly developed ornament and an obsolescent sulcus (Archbold 1981: 113). A few other species resemble *N. (S.) hardmani* in their stronger ornament, distinct sulcus and small size. Two such species are *Neochonetes pinegensis* (Kulikov, 1974) and *N. asseretoi* Fantini Sestini, 1964. *N. pinegensis*, from the Kazanian of the Pinega River, northern Russia, differs from *N. (S.) hardmani* in being widest at the hinge and in possessing a distinctive, concave dorsal valve (Likharev 1931, pl. 1, figs 15, 16, 20, 22, pl. 3, fig. 14). *N. pinegensis* has also been reported, with a query, from the Kazanian of the Kanin Peninsula (Stepanov et al. 1975: 57, pl. 1, figs 3, 4) but the material appears to represent a distinct species with strong sharp capillae and a narrow sulcus. *N. asseretoi*, from the Upper Rutch Formation of Iran, differs from *N. (S.) hardmani* in possessing a more pronounced ventral umbo. *N. armenicus* Sokolskaya (in Ruzhentsev & Saryeheva 1965: 209, pl. 32, figs 1–3; see also Grunt et al. 1974: 130, pl. 58, figs 3–5) from the Djhulfian of Armenia is of comparable size to *N. (S.) hardmani* but lacks a sulcus and possesses a distinctly concave dorsal valve.

Zone. Waagenoconcha imperfecta Zone (Archbold 1988a). Djhulfian.

Genus Waagenites Paeckelmann, 1930

(= *Dienerella* Reed, 1931)

Type species. Chonetes grandicosta Waagen, 1884.

Waagenites sp.

Fig. 5P–Q

Waagenites sp.—Archbold 1988a: 22, 27.

Comments. A single specimen (CPC 24512a, b) of a small ventral valve (4.1 mm wide, 4.4 mm long), consisting of both the external and internal moulds, is figured herein. The specimen is from the Upper Marine Beds, Port Keats Group, at locality PK 4 on the coast approximately 13.5 km north of Cape Dombey, Port Keats area, Northern Territory.

The specimen is subquadrate in outline with a distinct sulcus and a short posteriorly located median septum. Costellae are prominent and increase by bifurcation. They number about 2 per mm, are broad, somewhat flattened and are separated by narrow, sharp troughs.

This species is readily distinguished from *Waagenites stani* Archbold, 1988, from slightly older strata in the Canning Basin, by means of its distinctive sulcus, shell outline and pattern of costellae. Although the specimen is inadequate for detailed comparison with other species of the genus, its small size, strong costellae and distinct sulcus strongly recall *Waagenites aequicosta* (Waagen, 1884, pl. 60, fig. 7a–c) from the Cephalopoda-bed of the upper *Productus* Limestone of Jabi (Pakistan), Salt Range.

Zone. Waagenoconcha imperfecta Zone. Djhulfian.

Subfamily Svalbardiinae Archbold, 1982c

Genus Svalbardia Barkhatova, 1970

Type species. Chonetes capitolinus Toula, 1875b.

Svalbardia narelliensis Archbold, 1981

Fig. 6A–J

Svalbardia thomasi Archbold, 1981b (*partim*): 6, fig. 2E, S, R (*non cet.*).
Svalbardia narelliensis Archbold 1981d: 11, fig. 2A–Y.

Comments. Two species of *Svalbardia* have been described from the Permian of Western Australia. *S. narelliensis* Archbold, 1981d from beds near the top of the Noonkanbah Formation, Canning Basin, invariably lacks a sulcus and usually possesses weakly developed dorsal internal structures. The slightly younger *S. thomasi* Archbold, 1981b possesses a more distinct sulcus at maturity and strongly developed dorsal internal structures. Other features of the two species are similar.

The present suite of figured specimens, GSWA F43859–F43868, collected by Dr S. K. Skwarko from the Nalbia Sandstone at the same locality as *Neochonetes (Sommeriella) nalbiaensis* (GSWA locality 69568), are referrable to *S. narelliensis*. The absence of a sulcus in all of the ventral valves is noteworthy, and brachial ridges are extremely feebly developed at maturity. Previously figured specimens from the Nalbia Sandstone (Archbold 1981, fig. 2E, S, R) are here referred to *S. narelliensis* and as a result *S. thomasi* is now considered to be restricted to the Baker Formation.

Zone. Neochonetes (Sommeriella) nalbiaensis Zone. Early Kungurian.

Order Productida Saryeheva & Sokolskaya, 1959

Suborder STROPHALOSIIDINA Waterhouse, 1975
Superfamily STROPHALOSIACEA Schuchert, 1913
Family STROPHALOSIIDAE Schuchert, 1913
Subfamily STROPHALOSIINAE Schuchert, 1913

Genus **Heteralosia** King, 1938

Type species. Heteralosia slocomi King, 1938.

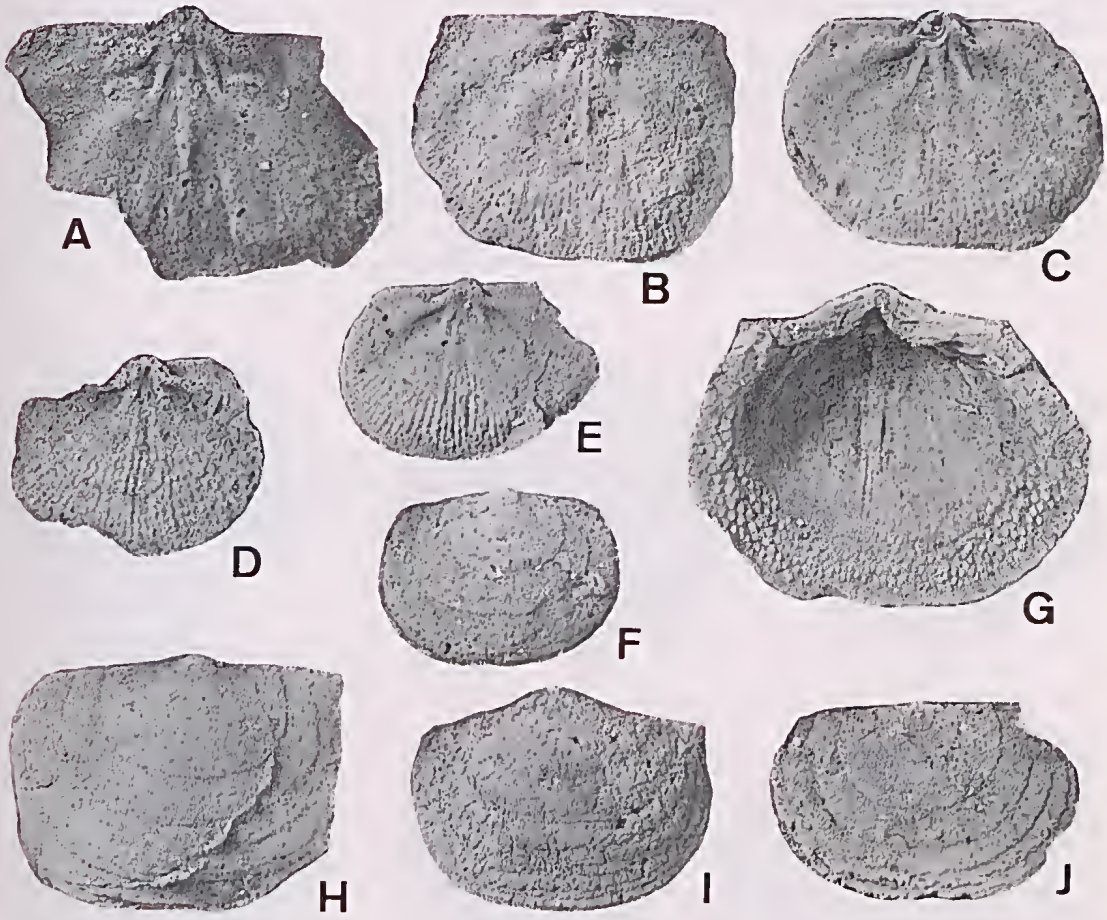
Subgenus **Heteralosia (Etherilosia)** subgen. nov.

Type species. Strophalosia etheridgei Prendergast, 1943.

Etymology. For R. Etheridge Junior, 1847–1920.

Diagnosis. Small to medium sized *Heteralosia* species with distinct rhizoid spines of attachment, distinct relatively large cicatrix of attachment, and uniform subcrect ventral spines.

Discussion. Heteralosia has previously been broadly interpretated by many authors including myself (Archbold 1986—see for review of previous literature). A re-examination of accounts of the type species by King (1938: 278, pl. 39, figs 15–18) and Muir-Wood & Cooper (1960: 80, pl. 3, figs 6–13) reveals some differences from Western Australian species previously re-



ventral valve external mould, × 3.5. G, GSWA F43865, latex cast of mature ventral valve internal mould, × 3.2. H, GSWA F43866, latex cast of ventral valve external mould, × 3. I, GSWA F43867, latex cast of ventral valve external mould, × 2.8. J, GSWA F43868, latex cast of dorsal valve external mould, × 3.2.

ferred to *Heteralosia*. These differences are considered to be of subgeneric importance and may assist in delineating lineages of species within *Heteralosia*.

Heteralosia (Etherilosia) lacks the two sets of spines (erect and prostrate) distributed over the entire ventral valve of *H. (Heteralosia)*, as described by Muir-Wood & Cooper (1960: 81). *H. (Etherilosia)* instead possesses uniform suberect spines over the ventral valve. *H. (Etherilosia)* is also characterised by a prominent cicatrix of attachment accompanied by fine, rhizoid spines which may attain a significant length in terms of shell size (Archbold 1986: 106, 108, figs 3K, V, 4M). Rhizoid spines are not a feature of *H. (Heteralosia) slocomi* (see Muir-Wood & Cooper 1960, pl. 3, figs 8–10).

The relatively large size of the cicatrix of attachment of Western Australian species such as *H. (Etherilosia) etheridgei* indicates that these species remained attached throughout life, unlike *H. (Heteralosia) slocomi*. It has been demonstrated elsewhere (Archbold 1986) that Western Australian species now referred to *H. (Etherilosia)* are not juveniles of larger species.

Heteralosia (Etherilosia) prendergastae (Coleman, 1957)

Fig. 7A–F

Comments. The revision of Western Australian species of *Heteralosia* by Archbold (1986) resulted in this species being restricted to one specimen. A small collection of specimens from AGSO Locality 7864 0142, described as "9 km WNW of Wandagee Homestead, bank of Minilya River, siltstone with mud clasts, probably basal Cundlego Formation, Carnarvon Basin", provides additional morphological data.

H. (E.) prendergastae is relatively large, up to 14.5 mm wide, with numerous semi-erect ventral spines scattered over the valve. Rhizoid spines are not well known but traces occur around the cicatrix of attachment. Valve interiors are typical of the genus.

The additional material appears to confirm the suggestion (Archbold 1986) that *H. (E.) prendergastae* is characterised by the possession of relatively numerous ventral spines in comparison with other species.

Fig. 7. Heteralosia (Etherilosia) prendergastae (Coleman). A, CPC 24513, ventral valve interior, × 3.2. B, CPC 24514, ventral valve exterior view, × 3.0. C, CPC 24515, dorsal valve interior view, × 4.0. D, CPC 24516, dorsal valve interior view, × 3.2. E, CPC 24517, dorsal valve interior view, × 3.2. F, CPC 24518, dorsal valve interior view, × 3.2.

Measurements (in mm).

Specimen	Hinge width	Maximum width	Ventral height	Dorsal height
CPC 24513	9.4	12.9	11.4	—
CPC 24514	9.5	14.5	13.0	—
CPC 24515	7.3	10.6	—	10.1
CPC 24516	11.1	14.3	—	11.2
CPC 24517	7.6	9.8	—	8.7
CPC 24518	8.8	12.2	—	10.6

Zone. Fusispirifer cundlegoensis Zone. Late Baigendzhinian.

Genus Wyndhamia Booker, 1929

Type species. Wyndhamia dalwoodensis Booker, 1929.

Comments. Western Australian species of *Wyndhamia* were reviewed by Archbold (1987) who noted that further detailed description was required in order to understand the nature of the type species. *Arcticalosia* Waterhouse (1986a) may have use as a genus or subgenus when the ventral spine pattern of *Wyndhamia* is fully understood. Western Australian species referred herein to *Wyndhamia* possess ventral spines of uniform size, as in *Arcticalosia*, rather than of two sizes as stated to be the case in *Wyndhamia* (Waterhouse 1986a: 2).

For the present study, material of *Wyndhamia* species from the Carnarvon Basin, described originally by Coleman (1957), was reinvestigated and the specimens are refigured (Fig 8). Specimen locality data are provided by Coleman (1957). The review of Coleman's specimens indicates that three distinct species are present in the Late Artinskian and Early Kungurian faunas of the Carnarvon Basin. The earliest of these species, *Wyndhamia multispinifera* (Prendergast) from the Cundlego Formation, is characterised by fine, uniform ventral spines with short spine bases and a brush of fine spines over the ventral ears (Coleman 1957, pl. 18, figs 3, 4, 6, 7, 11, 12, 14 and probably 13; see also Archbold 1987, fig. 3G–K, P–Q, fig. 4A–F). Enlarged illustrations of ventral valve exteriors (Fig. 8B, K) confirm the nature of the fine spines and the short nature of most spine bases. The species is restricted to the *Fusispirifer cundlegoensis* Zone of Archbold (in press).

The second species, herein referred to as *Wyndhamia* sp. A, is based on limited material from the Wandagee Formation (Coleman 1957, pl. 18, figs 5, 8–10; also figured herein Fig. 8F, G, J, L). This species is distinguished by its coarse ventral spines with relatively long spine bases (*W. colemani* Archbold, 1987 also possesses coarse ventral spines but lacks the long spine bases), distinctly convex dorsal interior (unlike that of *W. multispinifera* which is essentially flat), robust cardinal process (Coleman 1957, pl. 18, fig. 5) and distinct sulcus on the ventral valve. The species, occurring in the *Fusispirifer wandageensis* Zone of Archbold (in press), is not named because of the shortage of material.

The third species, herein referred to as *Wyndhamia* sp. B (see Archbold 1987, fig. 3L, M), is known only from a single incomplete dorsal valve from the Nalbia Sandstone (Early Kungurian). The flat nature of the dorsal interior suggests separation of the specimen from other known species of the genus. The species is restricted to the *Neochonetes (Sommeriella) nalbiaensis* Zone.

Suborder Productidina Waagen, 1883
Superfamily Linoproductacea Stehli, 1954
Family Linoproductidae Stehli, 1954
Subfamily Auriculispininae Waterhouse, 1986b

Genus Costatumulus Waterhouse, 1983a

Type species. Auriculispina tumida Waterhouse in Waterhouse et al. 1983.

Comments. Cancrinella was interpreted broadly by me in an earlier study (Archbold 1983). Numerous generic names are now available in order to split lineages of species formerly attributed to *Cancrinella*. This splitting is also made necessary by the observation that true *Cancrinella* possesses dorsal spines, as discussed and figured by Grigoryeva et al. (1977, pl. 19, fig 2e).

Western Australian species previously attributed by me to *Cancrinella* lack dorsal spines and appear to fall into three groups as follows.

1. A group of species with fine costellae, low narrow rugae and recumbent ventral spines with distinct spine ridges. Dorsal valves possess costellae and dimples and are very gently geniculate. These forms, which are now attributed to *Costatumulus*, include *Cancrinella irwinensis* Archbold, 1983, *Cancrinella* sp. A of Archbold (1983), and *Costatumulus occidentalis* sp. nov.

2. A rare species, described as *Cancrinella* sp. B by Archbold (1983), with coarse, prominent ventral rugae. This species is referred herein to *Maguiplicatina* Waterhouse, 1983b.

Fig. 8. A–E, H, I, K, *Wyndhamia multispinifera* (Prendergast). A, UWA 34457, dorsal valve, interior view, × 1.2. B, C, UWA 34454, ventral valve in ventral and interior views, × 1.3 and × 1.1. D, E, UWA 29057, ventral valve internal mould in ventral and anteroventral views, × 1. H, UWA 34456, dorsal valve, interior view, × 1.1. I, K, UWA 34455, ventral valve in interior and ventral views, × 1.2 and × 1.25. F, G, J, L, *Wyndhamia* sp. A. F, G, J, UWA 27454a, ventral valve in interior, ventral and posteroventral views, × 1.25, × 1 and × 1. L, UWA 27454b, dorsal valve, interior view, × 1.1.

3. A group of distinctive species with strongly enrolled ventral valves and with dorsal valves that lack spines, have a flat visceral disc and a striking genicular anteriorly. These species, herein referred to *Coolkilella* gen. nov., include *Cancrinella coolkilyaensis* Archbold, 1983 and *Productus bellus* Etheridge, 1918.

Whether the above genera should be treated as subgenera is perhaps arguable but in this study they are accepted as being of generic rank.

Costatumulus occidentalis sp. nov.

Fig. 9A–I

Linoproductus lyoni.—Coleman 1957 (*partim*): 76, pl. 8, figs 16–19, 22 (*non* 20, 21).
Lyonia lyoni.—Archbold 1983 (partim): 244.

Holotype. UWA 32025, an internal mould of a complete shell and the external mould of the dorsal valve, from Glendevon Homestead, Woolaga Creek, Irwin River area; High Cliff Sandstone (previously thought to be Fossil Cliff Formation), Aktastinian (Early Artinskian).

Other material. Paratypes: a ventral valve internal mould (UWA 32028) and an incomplete dorsal valve external mould (UWA 32028a).

Measurements (in mm).

Specimen	Hinge width	Maximum width	Ventral height	Dorsal height
UWA 32025	43	48	38	36
UWA 32028	43.5	47	38	—
UWA 32028A	—	—	—	33.5

Description. Large species, transverse in outline, hinge wide, maximum width of shell at mid-length. Relatively gently concavo-convex for genus.

Ventral valve evenly convex from umbo. Transverse profile evenly arcuate, no sulcus. Umbo low, protruding weakly above hinge line. Ears distinct, sharply demarcated from lateral flanks. Distinct row of hinge spines. Interior of valve reflects external ornament, muscle scars not developed.

Costellae prominent over ventral valve, absent on ears, rounded in cross section with narrow intercostal troughs, 10 per 5 mm at 15 mm from umbo, 8 per 5 mm at anterior of valve. Spine ridges higher and wider than costellae, arising anterior to spine ridges. Spine ridges up to 4.5 mm in length at anterior of ventral valve. Rugae prominent on ears, weaker over venter, relatively fine overall.

Dorsal valve gently concave with weak geniculation at anterior of valve. External ornament of costellae, rugae and dimples mirroring the ventral valve ornament. Ears weakly demarcated from visceral disc. Dorsal interior with median septum approximately half as long as visceral disc. Cardinal process poorly known, appears to be typically linoproductid.

Comments. Costatumulus occidentalis sp. nov. is larger than the other Western Australia species *C. irwinensis* (Archbold) and the poorly known *Cancrinella* sp. A (Archbold 1983). *C. tumidus* (Waterhouse) from the Artinskian Tiverton Formation of the Bowen Basin, Queensland, possesses finer costellae than the new species.

Costatumulus apparently occurs also in north-eastern Siberia in the Permian of Verkhoyanya. Some specimens referred to *Cancrinella grandis* Solomina, 1981 (see Abramov & Grigoryeva 1988: 123, pl. 10, fig. 19, pl. 11, figs 1–4) appear to lack dorsal spines and recall *C. occidentalis* in size and ornament, although costellae are finer on the specimens described by Abramov & Grigoryeva. The type specimens of *C. grandis* possess dorsal spines (Solomina 1981).

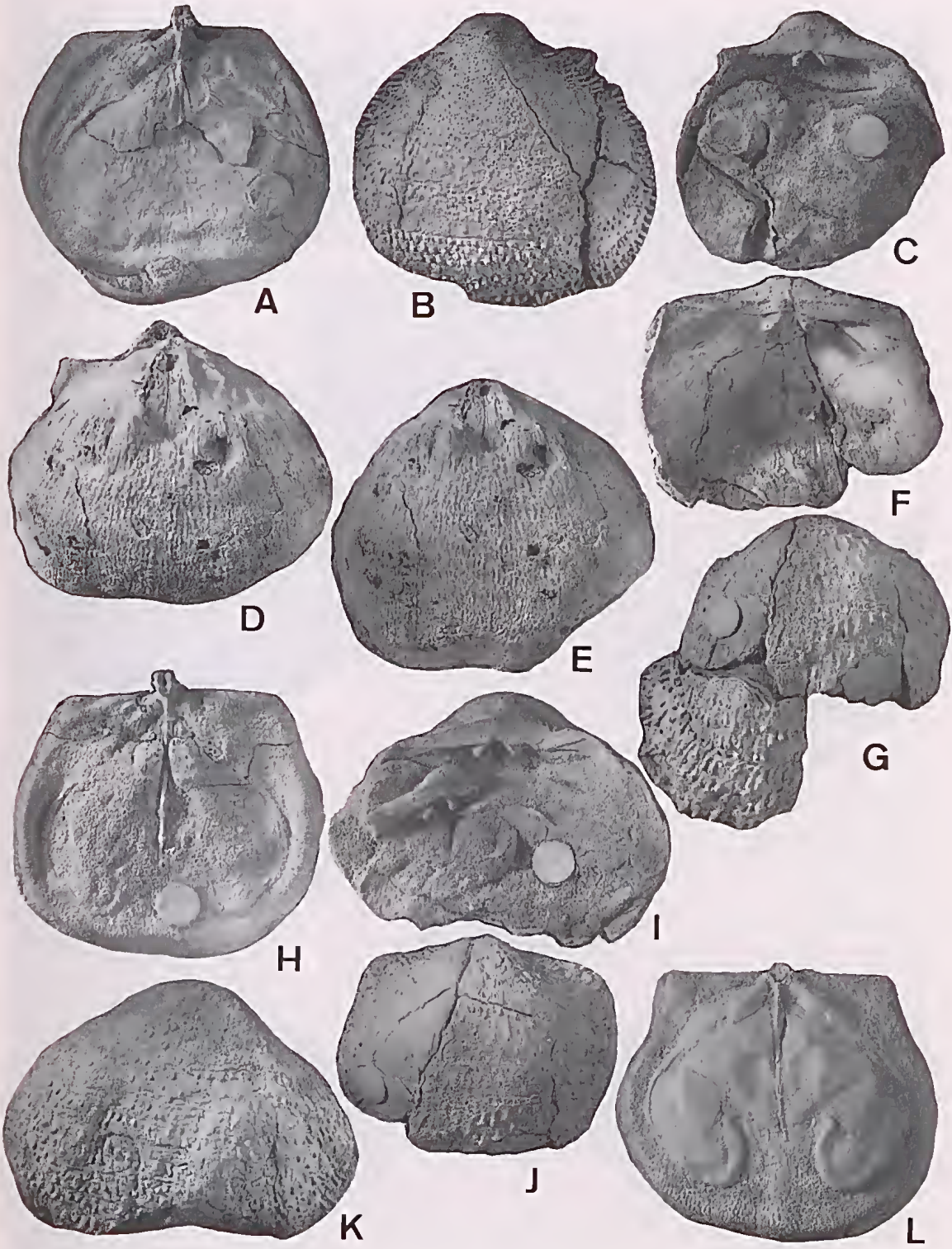
Zone. Neochonetes (Sommeriella) sp. nov. A Zone. Aktastinian (Early Artinskian).

Genus Coolkilella gen. nov.

Type species. Cancrinella coolkilyaensis Archbold, 1983.

Diagnosis. Auriculispininae with strongly enrolled ventral valve and dorsal valve with flat or very gently concave visceral disc and pronounced geniculation anteriorly. Ventral spines present but dorsal spines absent. Ventral rugae weakly developed.

Discussion. With the restriction of *Cancrinella* to species with dorsal spines, a distinctive group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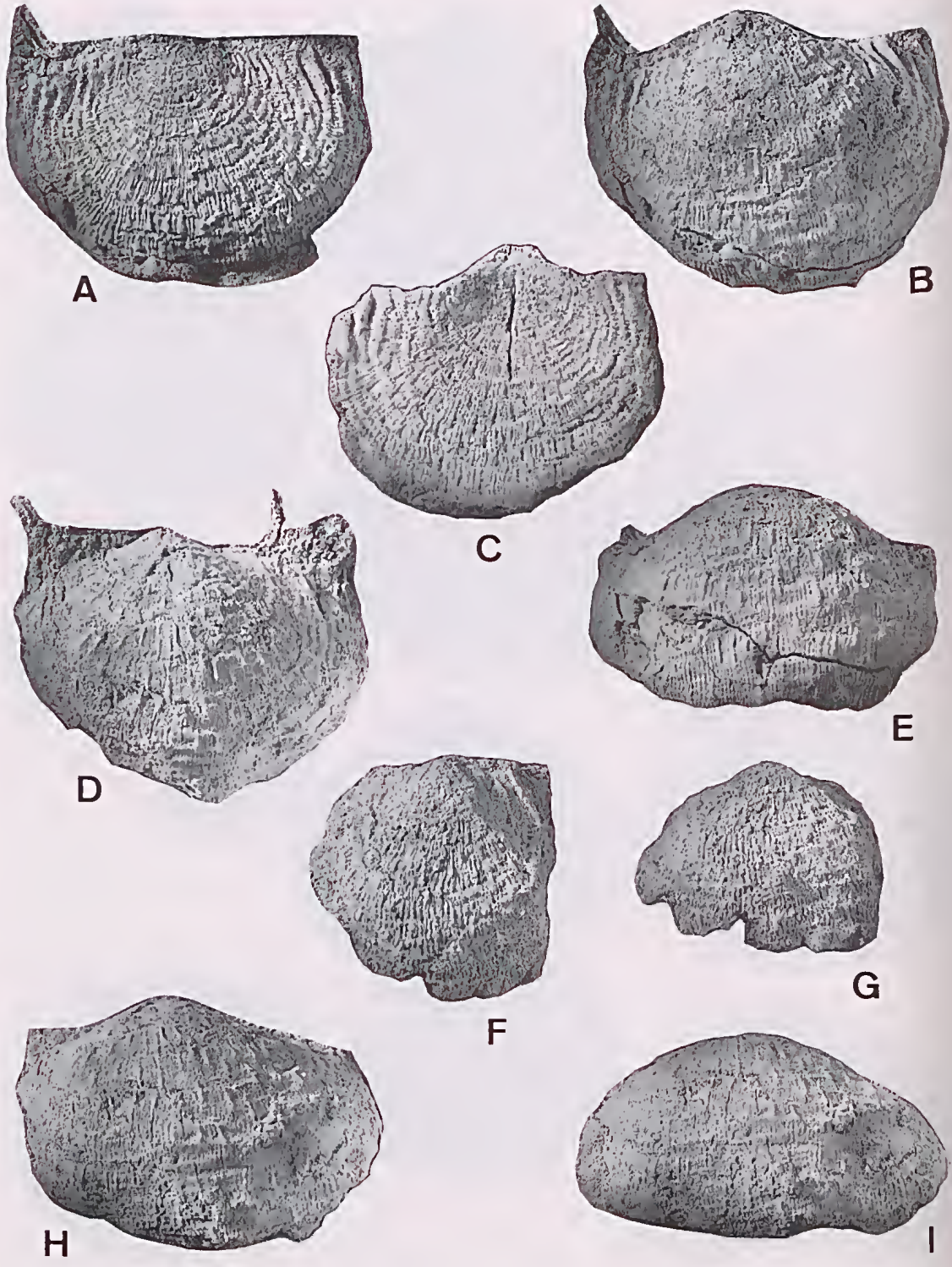
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Fig. 9. Costatumulus occidentalis sp. nov. A–C, E, UWA 32025, holotype, dorsal valve external mould and internal mould of shell in ventral, dorsal and anterior views, × 1.1. D, H, I, UWA 32028, ventral valve internal mould in ventral, anteroventral and anterior views, × 1.1. F, G, UWA 32028a, incomplete dorsal valve external mould in full and anterior views, × 1.1.

of Western Australian species requires a new generic name. Neither *Costatumulus* nor *Magniplicatina* are suitable, as implied above. Ganelin (in Kashik 1990) has proposed the generic names *Kolymaella* and *Omolonia* for certain species previously included in *Cancrinella*. *Kolymaella*, with type species *Cancrinella ogonerensis* Zavodovsky (1960a: 65, pl. 1, figs 13, 14), recalls *Costatumulus* and appears to lack dorsal spines. The dorsal valve is very gently geniculated. *Omolonia*, with type species *Cancrinella snjatkovi* Zavodovsky (1960c: 323 pl. 79, figs 7–9), represents a distinctive form with numerous fine spines with short spine bases closely scattered over the ventral valve and hence is not close to *Coolkilella* gen. nov.

The most striking feature of *Coolkilella coolkilyaensis*, from the Kungurian Coolkilya Formation of the Carnarvon Basin, is the extraordinary development of the geniculation at the anterior of the essentially flat visceral disc (Archbold 1983, fig. 2M–O). This feature of the dorsal valve recalls *Terrakea* Booker, 1930 but that genus possesses prominent dorsal spines, unlike *Coolkilella*.

Coolkilella bella (Etheridge, 1918)

Fig. 10A–C

Cancrinella bella.—Archbold 1983: 241, figs 1Q–X, 2A, B (with synonymy).

Comments. My earlier review of this species was primarily restricted to specimens from the Noonkanbah Formation, Canning Basin (Archbold 1983). Coleman (1957) described specimens of this species from the Wandagee Formation, Carnarvon Basin. One of those specimens is refigured herein in order to illustrate the strongly enrolled nature of the ventral valve and the distinctive ornament of ventral spine bases that normally give rise to one costella at the anterior of each base. The strongly developed dorsal geniculation of the dorsal valve of *Coolkilella bella* was illustrated by Coleman (1957, pl. 8, figs 5, 6) in a submature dorsal valve.

Coolkilella bella is distinguished from *C. coolkilyaensis* by the former species' extremely weakly developed ventral rugae across the venter. *Cancrinella* sp. of Archbold (1982b, pl. 2, figs 12–19) from the Late Artinskian or Early Kungurian of Irian Jaya may be allied to *Coolkilella* as it possesses spine bases that often give rise to only a single costella. The dorsal valve of the Irian Jayan species is unknown.

Zone. *Fusispirifer wandageensis* Zone. Latest Artinskian to Early Kungurian.

Superfamily PRODUCTACEA Gray, 1840
Family DICTYOCLOSTIDAE Stehli, 1954

Genus **Costiferina** Muir-Wood & Cooper, 1960

Type species. *Productus indicus* Waagen, 1884.

Costiferina wadei (Prendergast, 1943)

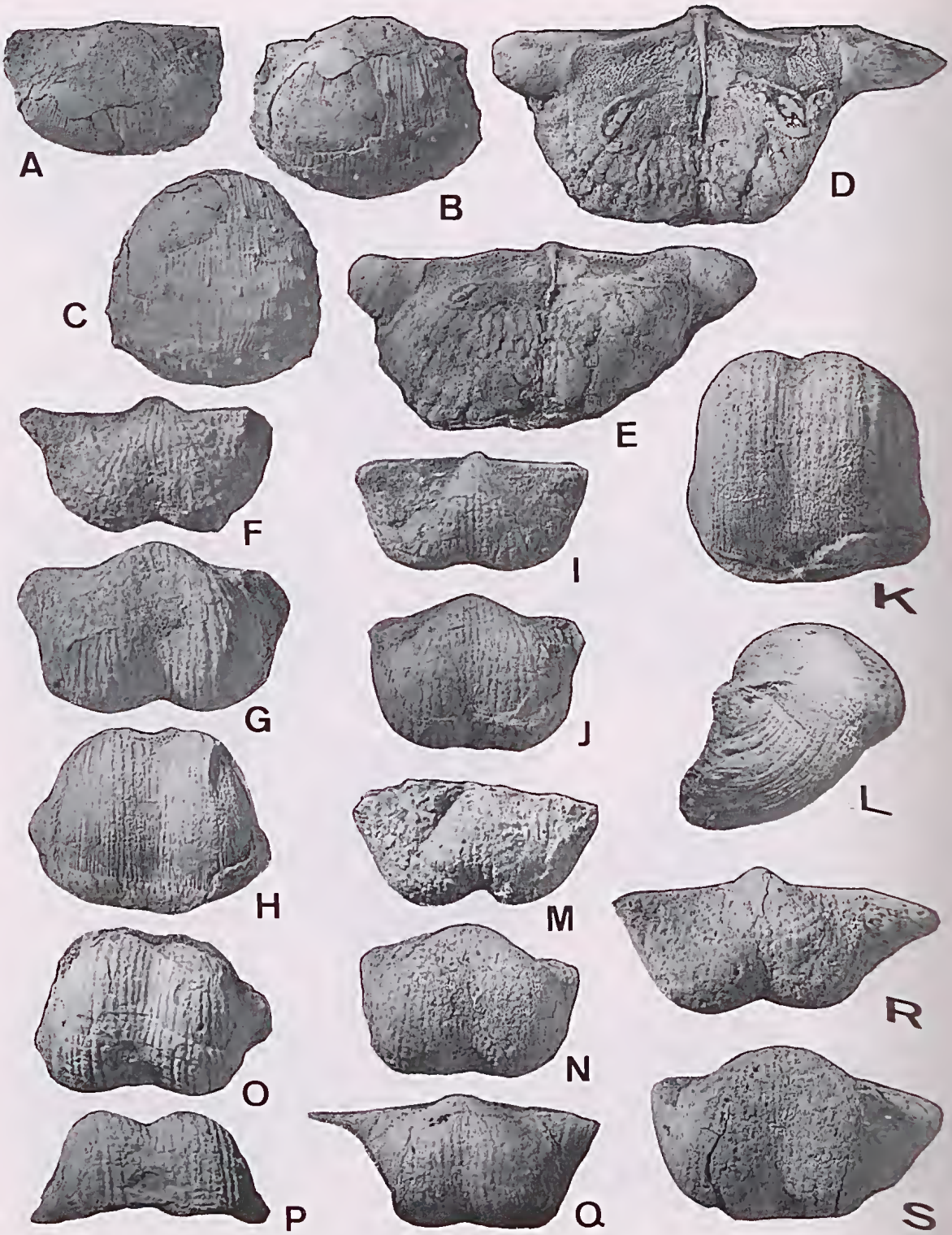
Fig. 10D–E

Costiferina wadei.—Archbold 1985: 24, fig. 4A–L (with synonymy).

Comments. Previous descriptions of *C. wadei* by Prendergast (1943), Coleman (1957) and Archbold (1985) did not include precise details of the dorsal valve interior because of a lack of well preserved material. A single dorsal valve (CPC 24519) from AGSO locality KNA 17 (described as a measured section of the Noonkanbah Formation, south of Grant Range, Canning Basin, about 13 km (8 miles) bearing 120° from Mount Anderson homestead, approximately 50 m above the base of the section) provides details of the dorsal interior.

The interior of the dorsal valve is strongly geniculated. The median septum arises at the base of the cardinal process and extends across the visceral disc with a blade-like termination. Adductor scars are distinct and dendritic. Brachial ridges are distinct and arise at a low angle. Posterior lateral ridges are prominent and the marginal ridge on the lateral margins of the visceral disc are low. The coarse costae on the exterior of the trail are reflected on the interior. Details of the dorsal interior confirm the assignment of the species to *Costiferina*.

Zone. As discussed briefly in Archbold (in press), the age of *C. wadei* may be as old as the *Eolinalosia prideri* Zone (Early Baigendzhinian, Artinskian) but evidence is equivocal.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Family MARGINIFERIDAE Stehli, 1954

Genus **Retimarginifera** Waterhouse, 1970

Type species. Retimarginifera perforata Waterhouse, 1970.

Retimarginifera perforata Waterhouse, 1970

Fig. 10F–S

Retimarginifera perforata.—Archbold 1984: 116, fig. 2A–X, AA (with synonymy).

Comments. Two species of *Retimarginifera,* including the type species, are recognised from the Permian of Western Australia (Archbold 1984a). Coleman (1957) and Condon (1967) recorded the genus from various formations in the Carnarvon Basin and Coleman also recorded it from the Noonkanbah Formation of the Canning Basin. My previous review of the genus was only able to confirm the occurrence of the genus in the Cundlego, Wandagee and Coolkilya Formations of the Carnarvon Basin. While searching through the Canning Basin collections of the AGSO, a small suite of specimens was discovered from the Noonkanbah Formation, confirming Coleman's (1957) report. The specimens (CPC 24520–24523, 30868–30870), all from AGSO locality KNA 29 (described as about 13 km bearing 120° from Mount Anderson Homestead, about 277 m (910 feet) above base of measured section), conform to previous descriptions of the species.

Zone. The possibility of recognising zones based on brachiopods within the Noonkanbah Formation was implied by Thomas (1958a: 24), and additional data to support this view are provided by Archbold (in press). The present material probably indicates an horizon in the Noonkanbah Formation belonging to the *Fusispirifer cundlegoensis* Zone.

Family WAAGENOCONCHIDAE Muir-Wood & Cooper, 1960
Subfamily WAAGENOCONCHINAE Muir-Wood & Cooper, 1960

Genus **Waagenoconcha** Chao, 1927

Type species. Productus humboldtii d'Orbigny (1842: 54, pl. 5, figs 4–7) from the early Permian of Yarbichambi, Bolivia.

Comments. The genus has been well described by Coleman (1957), Grant (1966) and Cooper & Grant (1975). The type species has been figured extensively from the type region by Kozlowski (1914, pl. 7, figs 1–9), Muir-Wood & Cooper (1960, pl. 89, figs 6–10), Branisa (1965, pl. 64, figs 11–19) and Samtleben (1971, pl.2, figs 17–19). The syntypic series of d'Orbigny (1842) was refigured by Tschernyschew (1904: 31, figs T1–T3a). No lectotype of *Productus humboldtii* has been selected by subsequent workers, so I select as lectotype the specimen figured by Tschernyschew (1904: 31, figs T1 and T1a). It was said by Tschernyschew to be housed in the d'Orbigny collection of the Museum d'Histoire Naturelle, Paris.

Large Permian specimens from Bear Island figured by Wiman (1914, pl. 14, figs 8, 9, pl. 15, figs 1, 2, pl. 16, figs 1–4) as *P. humboldtii* were named *Ruthenia wimani* by Fredericks (1934: 28). This species was chosen by Waterhouse (1983b: 125) as type species of the new genus *Wimanoconcha*, which was briefly diagnosed as typically possessing an "externally flat, anteriorly thickened dorsal valve, with subcrenulate hinge". An examination of Wiman's excellent illustrations indicates that his specimens are gerontic individuals. Large dendritic adductor scars and distinct brachial ridges are present in the dorsal valve, which is gently concave externally with a distinct median fold. The hinge line is straight and the ventral sulcus is distinct early in ontogeny but flattens out anteriorly in gerontic specimens.

Wimanoconcha appears to have value as a subgenus of *Waagenoconcha*, but for reasons different to those provided by Waterhouse (1983b). Large species of *Waagenoconcha* typically possess a long trail with crenulations developing radially on the flanks and centre of the trail (Wiman 1914, pl. 15, fig. 1, pl. 16, fig. 2). Dorsal valves may develop weak crenulations at

Fig. 10. A–C, *Coolkilella bella* (Etheridge), AMF 38455, ventral valve in posterior, ventral and anteroventral views, × 1.25. D, E, *Costiferina wadei* (Prendergast), CPC 24519, dorsal valve in interior and anterior views, × 1. F–S, *Retimarginifera perforata* Waterhouse. F–H, CPC 24520, ventral valve in posterior, ventral and anterior view, × 2. I, J, CPC 24521, ventral valve in posterior and ventral views, × 2. K, L, CPC 24522, ventral valve in anterior and lateral views, × 2. M, N, CPC 24523, ventral valve in posterior and ventral views, × 2. O, P, CPC 30868, ventral valve in ventral and anterior views, × 2. Q, CPC 30869, ventral valve in ventral view, × 2. R, S, CPC 30870, ventral valve in posterior and ventral views, × 2.

the anterior margin (Kalashnikov 1986, pl. 121, fig. 7b) and become thickened anteriorly and internally in the region of the visceral disc. These distinctions serve to characterise the subgenus *Wimanoconcha*.

Subgenus Waagenoconcha (Wimanoconcha) Waterhouse, 1983

Type species. Ruthenia wimani Fredericks, 1934.

Comments. Large specimens referred to Fredericks's species have been recorded throughout the Arctic from areas such as East Greenland (Dunbar 1955), Spitzbergen (Stepanov 1936, Gobbett 1964), the northern Timan (Kalashnikov 1986), the Pechora Basin and the Pay-Khoy (Ifanova 1972, Solomina 1960), the Taimyr Peninsula (Einor 1946), the Verkhoyansk (Abramov & Grigoryeva 1988) and the Kolyma–Omolon region (Saryeheva 1984). Large species from Inner Mongolia attributed to *Waagenoconcha* (Lee et al. 1984, 1985) also belong in *Wimanoconcha*. Specimens referred to various varieties of *Productus (Ruthenia) pnrdoni* by Reed (1944, pl. 13, figs 1–6, pl. 14, figs 1–6) from the Salt Range, Pakistan, are also allied.

Based on the new material illustrated herein, the Western Australian species *Waagenoconcha imperfecta* Prendergast is assigned to *Wimanoconcha* on the basis of the morphology of mature specimens.

Waagenoconcha (Wimanoconcha) imperfecta Prendergast, 1935

Figs 11A–H, 12A–K, 13A–G

Waagenoconcha imperfecta Prendergast 1935: 15, pl. 4, figs 1–3.—Prendergast 1943: 25, pl. 3, figs 7–9.—Coleman 1957: 82, pl. 10, figs 8–14, pl. 11, figs 1–6.—Archbold 1988: 22.

Waagenoconcha vagans.—Prendergast 1943: 26, pl. 3, fig. 6.

cf. *Waagenoconcha imperfecta.*—Tazawa 1974: 127, pl. 1, figs 4–6, pl. 2, figs 2–7, pl. 3, figs 1–3, pl. 4, figs 1–4, 7.

Holotype. A submature shell, UWA 3044, from Luluigui Station, west Kimberley district; Hardman Formation, Cherrabun Member, Canning Basin.

Material. CPC 30871–30872, two internal moulds of shells from AGSO Locality KLC 42, near Tutu Bore, Nerrima Station, on flank of Dry Corner Syncline, north-west of Nerrima Dome. CPC 30873, an internal mould of a dorsal valve from AGSO locality M3, Lat. 19°12′S, Long. 125°32′E, central Millyit Range. CPC 30874–30884, a ventral valve, five complete dorsal valves, four incomplete dorsal valves and an external mould of a dorsal valve, all from AGSO locality KLB 11, from beds 1.25 m thick at about 40 m below top of Mount Hardman. All Cherrabun Member of Hardman Formation, Canning Basin.

CPC 30885–30886, a dorsal valve internal mould and an incomplete ventral valve internal mould, from AGSO locality PK1, Tchindi Beach, west of Port Keats Mission. CPC 30887–30888, two fragments of dorsal valves, from AGSO locality PK4 on coast approximately 13.5 km north of Cape Dombey, Port Keats area, Northern Territory. Upper Marine Beds, Port Keats Group.

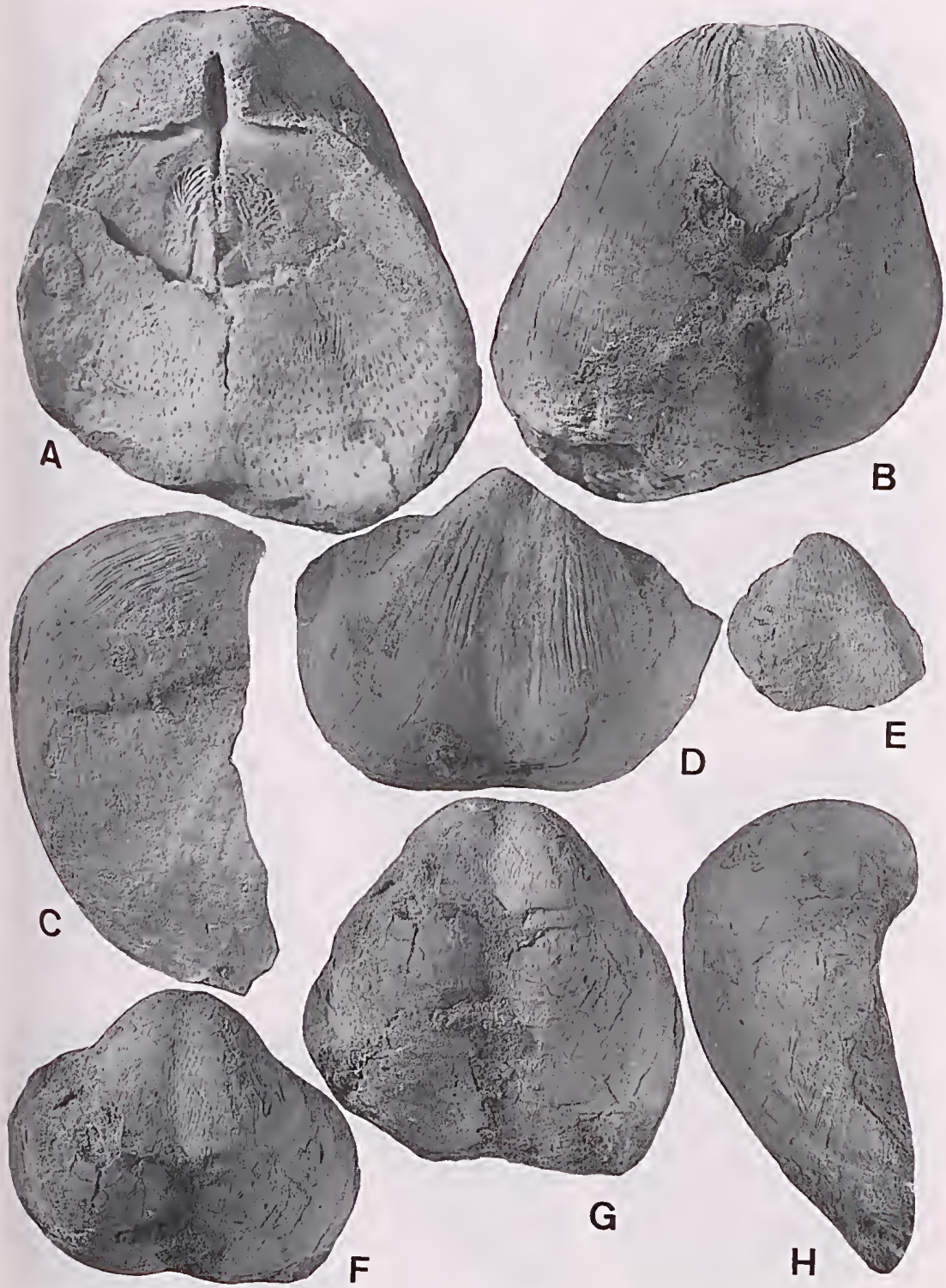
Comments. This species was described by previous authors (Prendergast 1935, 1943; Coleman 1957) on the basis of chiefly submature individuals. The new material illustrated herein provides additional details on the maximum size of individuals and the nature of mature dorsal valves, and documents the species from the Port Keats Group.

The largest of the specimens show the development of radial crenulations of the shell on the flanks of the ventral trail (Fig. 11A, H). The ventral sulcus also flattens anteriorly on these specimens. Mature dorsal valves show the initial appearance of visible brachial ridges (Figs 11A, 13A, C). The cardinal process develops from a short, weakly lobate structure in juvenile specimens (Figs 12C, 13E) to a strongly trilobate feature at submaturity (Fig. 12D–H). Gerontic dorsal valves show distinct thickening of the valve and the cardinal process takes on a blunt appearance (Fig. 13A).

Specimens attributed to *Productus waageni* by Broili (1916, pl. 118, figs 1–5) from the Upper Permian of Timor were considered by Prendergast (1943) and Coleman (1957) to be representatives of *Waagenoconcha (Wimanoconcha) imperfecta*. While the two species are similar in many details, they are distinguished by the nature of the spine bases (see Archbold & Bird 1989).

Tazawa (1974) referred to *Waagenoconcha (Wimanoconcha) imperfecta* an extensive suite of specimens from the upper part of the Lower Kanokura Series, southern Kitakami Mountains, north-east Japan. The specimens are ger-

Fig. 11. A–H, *Waagenoconcha (Wimanoconcha) imperfecta* Prendergast. A–D, CPC 30871, internal mould of shell in dorsal, ventral, profile and posterior views, × 1. E, CPC 30872, internal mould of shell in ventral view, × 1.2. F–H, CPC 30873, ventral valve in posterior, ventral and profile views, × 1.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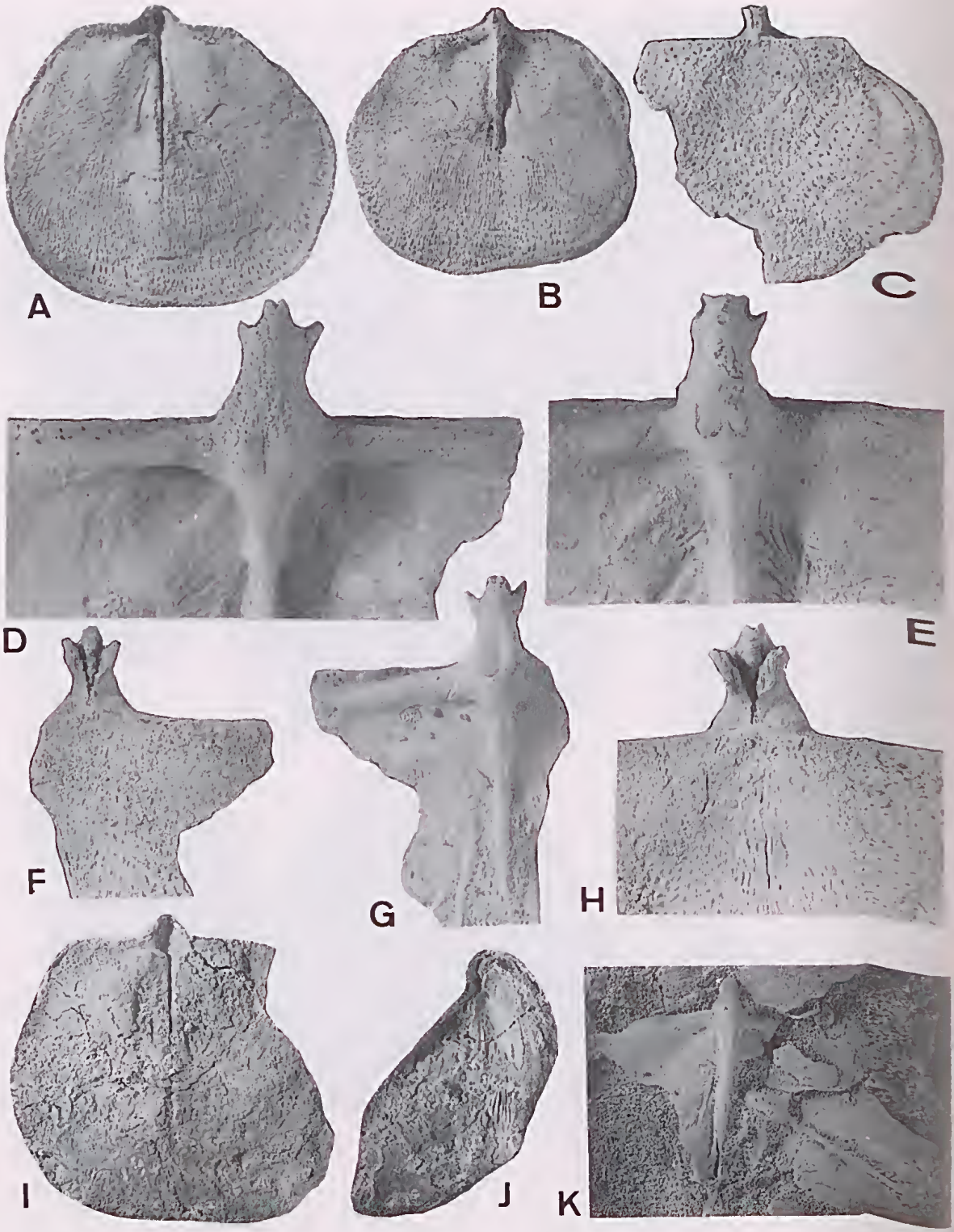
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Fig. 12. A–K, *Waagenoconcha (Wimanoconcha) imperfecta* Prendergast. A, B, CPC 30874, internal mould of dorsal valve and latex cast from mould, × 1.3 and × 1.1. C, CPC 30880, juvenile dorsal valve in dorsal view, × 3.2. D, H, CPC 30881, cardinal process of incomplete dorsal valve, × 3.5. E, CPC 30882, cardinal process of incomplete dorsal valve, × 3.5. F, G, CPC 30883, cardinal process of incomplete dorsal valve, × 3.2. I, CPC 30885, internal mould of dorsal valve, × 1. J, CPC 30886, incomplete internal mould of ventral valve, × 1. K, CPC 30887 and CPC 30888, incomplete fragments of dorsal valves, × 1.

erally smaller than Australian material but otherwise are close. I leave them as a comparison in the synonymy above.

Waterhouse (1969a: 723; 1982a: 41, pl. 8, fig. a) attributed a poorly preserved, incomplete ventral valve and numerous "fragments of external moulds" from the Arthurton Group, New Zealand, to *Waagenoconcha* aff. *imperfecta*. Examination of a latex cast of the figured ventral valve (supplied by Dr Hamish Campbell, New Zealand Geological Survey) indicates that the specimen may be a waagenoconchinid but that the generic and specific identifications are premature and should await the discovery of additional well preserved specimens.

Zone. Waagenoconcha (Wimanoconcha) imperfecta Zone (Archbold 1988a). This zone, of Djhulfian age, is the youngest marine Permian zone of the Australian continent (Archbold in press).

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Syringothyridacea Fredericks, 1926
Family Syringothyrididae Fredericks, 1926
Subfamily Permosyrinxinae Waterhouse, 1986

Genus **Cyrtella** Fredericks, 1924

Type species. Cyrtia kulikiana Fredericks, 1916.

Cyrtella sp.

Fig. 14A–C

Comments. Two specimens (NMV P120351, a dorsal valve, and GSWA 43869, a broken ventral valve) from the Fossil Cliff Formation, Perth Basin, are figured in order to document the occurrence of **Cyrtella**, or a related genus, from the formation. The two specimens are inadequate for detailed comparison with the Carnarvon Basin Tastubian–Sterlitamakian species *Cyrtella australis* Thomas, 1971 or the Sterlitamakian Canning Basin species *Cyrtella koopi* Archbold, 1990, but the costal details suggest a closer relationship with the former species.

Zone. Strophalosia irwinensis Zone. Sterlitamakian.

Superfamily Spiriferacea King, 1846
Family Spiriferidae King, 1846
Subfamily Spiriferellinae Waterhouse, 1968

Genus **Spiriferella** Tschernyschew, 1902

Type species. Spirifer saranae de Verneuil, in Murchison et al. 1845.

Spiriferella australasica (Etheridge, 1889)

Fig. 14D–G

Spiriferella australasica.—Archbold & Thomas 1985a: 39, figs 1BB–HH, 2A–M (with synonymy).

Comments. A single specimen (WAM 87.475) from the Wandagee Formation at a general locality on the Minilya River, Wandagee Station, Carnarvon Basin is illustrated fully to show the details of the fastigium of the dorsal valve. The fastigium was one of the few details of *S. australasica* not able to be fully described by Archbold & Thomas (1985a). The present specimen shows that a shallow median groove arises on the peak of the fastigium and persists to the anterior margin of the valve, with the anterior margin fold being distinct but flat-topped. Other details of the specimen conform with the species description provided by Archbold & Thomas (1985a).

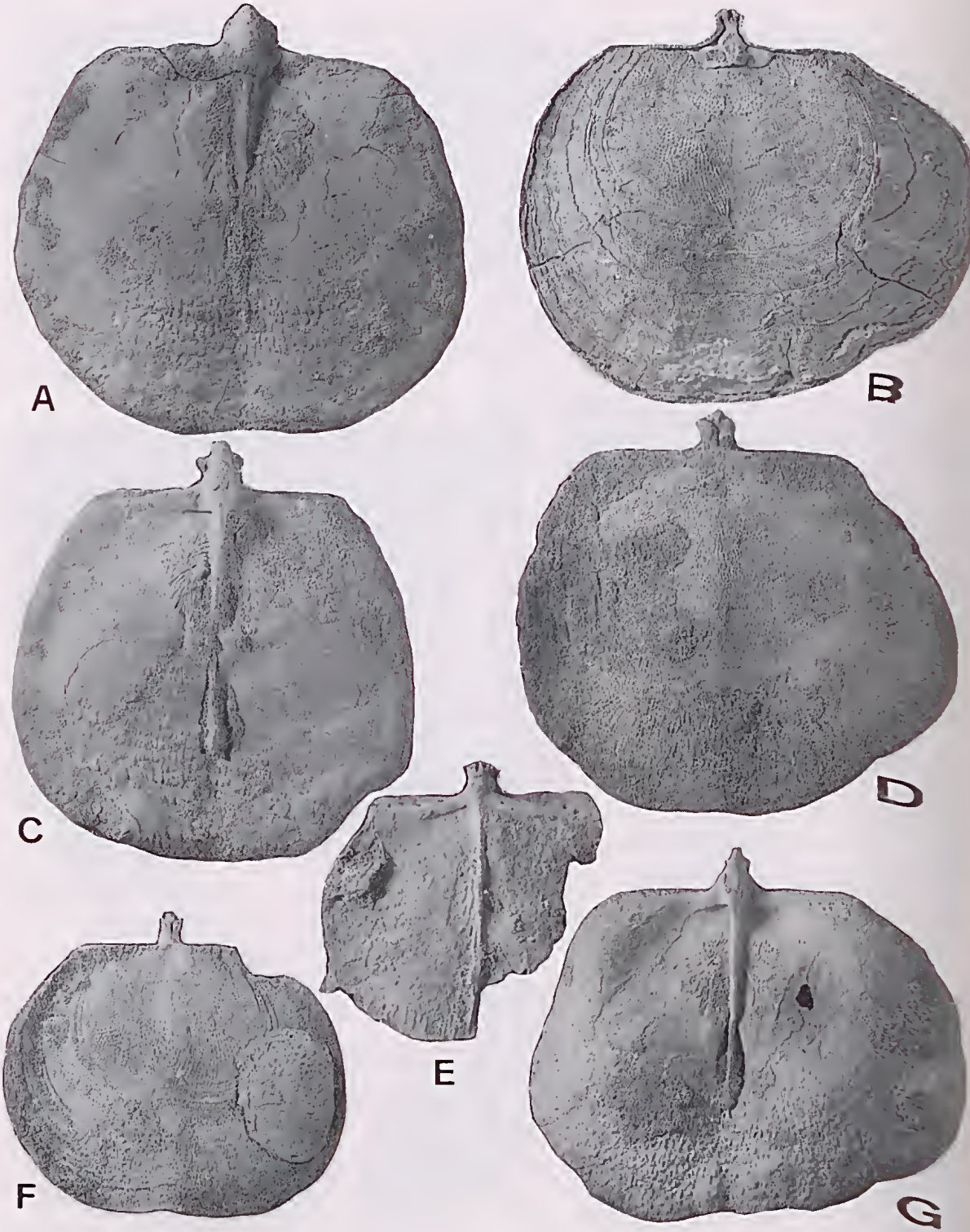
Zone. Fusispirifer wandageensis Zone. Latest Baigendzhinian to earliest Kungurian.

Subfamily Neospiriferinae Waterhouse, 1968

Genus **Cartorhium** Cooper & Grant, 1976

Type species. Cartorhium retusum Cooper & Grant, 1976.

Comments. The genus was fully described by Cooper & Grant (1976). The new species described below is based on a single remarkable specimen that does not readily fall into any other genus of the Neospiriferinae, as defined by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Archbold & Thomas (1984b). Although only one specimen is available, it is so unlike any other Western Australian neospiriferid that it is formally named as a new species.

Cartorhium imperfectum sp. nov.

Fig. 14H–K

Holotype. NMV P120352, an internal mould of a conjoined shell with portion of the shell remaining near the umbonal regions, from UWA locality WC 19, north-east of east fence of Mungadan Paddock, Wandagee Station; Wandagee Formation, Carnarvon Basin. Collector Dr C. Teichert.

Measurements. Maximum width, 53.0 mm estimate; hinge width, 40 mm estimate; height of ventral valve, 37.8 mm; height of dorsal valve, 35.2 mm; thickness of shell, 24.9 mm.

Description. Moderate sized species, transversely subelliptical. Maximum width at approximately half shell length. Hinge width relatively narrow. Ears absent.

Ventral umbo small, rounded and overhanging low, relatively narrow interarea. Sulcus absent at early ontogenetic stages, anteriorly developed as a broad flattening of valve with a broad weakly developed sulcal tongue. Ventral valve flanks barely plicate. Costae equidimensional, bifurcate once early in ontogeny and once more later in ontogeny, resulting in fascicles of normally 4 costae at anterior margin of valve. Costae broad, rounded with narrow intercostal troughs, between 6 and 7 costae per cm at anterior of valve. Ventral interior apical structures unknown.

Dorsal fastigium barely discernible from lateral flanks of dorsal valve, resulting in low, broad fold at anterior margin. Lateral plications not developed on valve flanks. Costae on anterior of valve comparable to ventral costae. Dorsal apical structures not known except for delicate median myophragm extending for 12 mm anterior to cardinal process.

Discussion. The specimen appears most closely allied to species of *Cartorhium* but differs in its finer costae and broader anterior sulcus and low, broad fold. Species assigned by Reed (1944) to *Purdonella* are also allied but again do not possess a low, broad fold.

Zone. Fusispirifer wandageensis Zone. Latest Baigendzhinian to Early Kungurian.

Superfamily uncertain
Family INGELARELLIDAE Campbell, 1959
Subfamily INGELARELLINAE Campbell, 1959

Genus **Tomiopsis** Benediktova, 1956

Type species. Brachythyris kumpani Yanishevskiy, 1935.

Tomiopsis hardmani Archbold & Thomas, 1986

Fig. 14L, M

Comments. This species was fully described by Archbold & Thomas (1986a) but the micro-ornament was poorly known. A single natural cast of a dorsal valve (CPC 19851) from AGSO locality CR 1565, described as Lat. 19°04′00″S, Long. 125°08′30″E, Kirkby Range Member, Hardman Formation, Canning Basin, Crossland mapsheet area, provides details of the micro-ornament. This consists of elongate, narrow, shallow surface grooves arranged in a subquincunx pattern and hence is diagnostic of *Tomiopsis.*

Zone. The species occurs in both the *Liveringia magnifica* and *Waagenoconcha (Wimanoconcha) imperfecta* Zones of Archbold (1988a). Midian to Djhulfian.

Superfamily RETICULARIACEA Waagen, 1883
Family ELYTHIDAE Fredericks, 1924
Subfamily ELYTHINAE Fredericks, 1924

Genus **Spirelytha** Fredericks, 1924

Type species. Spirelytha pavlovae Archbold & Thomas, 1984.

Spirelytha kashirtsevi sp. nov.

Fig. 15A–D

Spirelytha sp. B.—Archbold & Thomas 1984a: 322, fig. 4X–Z, AA.

Holotype. A natural cast of a shell, CPC 24231, from the Quinnanie Shale, Carnarvon Basin. Full locality

Fig. 13. A–G, *Waagenoconcha (Wimanoconcha) imperfecta* Prendergast. A, CPC 30875, gerontic dorsal valve, interior view, × 1. B, CPC 30884, external mould of large dorsal valve, × 1. C, CPC 30876, dorsal valve, interior view, × 1. D, CPC 30877, dorsal valve external view, × 1. E, CPC 30880, juvenile dorsal valve, interior view, × 3.2. F, CPC 30878, submature dorsal valve, exterior view, × 1. G, CPC 30879, mature dorsal valve, interior view, × 1.

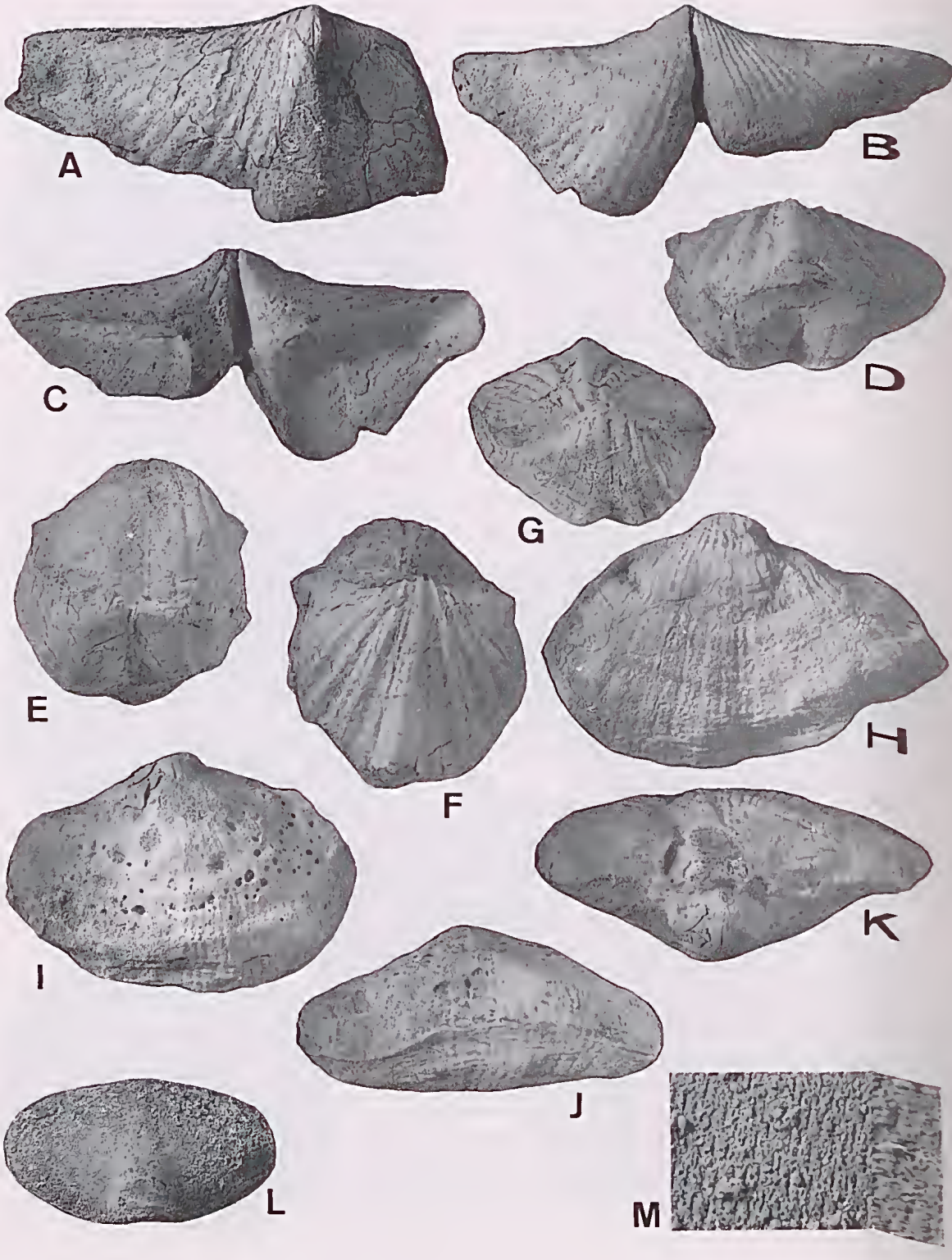
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Fig. 14. A–C, *Cyrtella* sp. A, NMV P120351, incomplete dorsal valve in dorsal view, × 1. B, C, GSWA 43869, broken ventral valve in ventral and dorsal views, × 1.3. D–G, *Spiriferella australasica* (Etheridge), WAM 87.475, shell in ventral, dorsal, posterior and anterior views, × 1. H–K, *Cartorhium imperfectum* sp. nov., NMV P120352, holotype, internal mould of shell in ventral, dorsal, anterior and posterior views, × 1. L, M, *Tomiopsis hardmani* Archbold & Thomas, natural cast of dorsal valve, × 1, and portion of surface enlarged, × 8.

details were provided by Archbold & Thomas (1984a).

Etymology. For Arkady Sergeevich Kashirtsev, Soviet palaeontologist and geologist.

Measurements. Maximum width, 23.5 mm; hinge width, 15.5 mm; height of ventral valve, 17.5 mm; height of dorsal valve, 17.4 mm; thickness, 12.0 mm.

Diagnosis. Equally convex valves with ventral interarea at 90° to plane of dorsal valve. Moderate size for genus, transversely oval in outline. Ventral umbo low, pointed and overhanging interarea. Sulcus distinct, broad, U-shaped in cross section. Delthyrium large, triangular. Dorsal umbo small, sharp. Fastigium very low, only visible on anterior half of valve. Fold low, rounded.

Concentric lamellae coarse, about 7 per cm at 1.5 cm from umbones, carrying poorly preserved biramous spine bases, about 2 per mm at 1 cm from umbones. Interior unknown. Anterior commissure parasulcate.

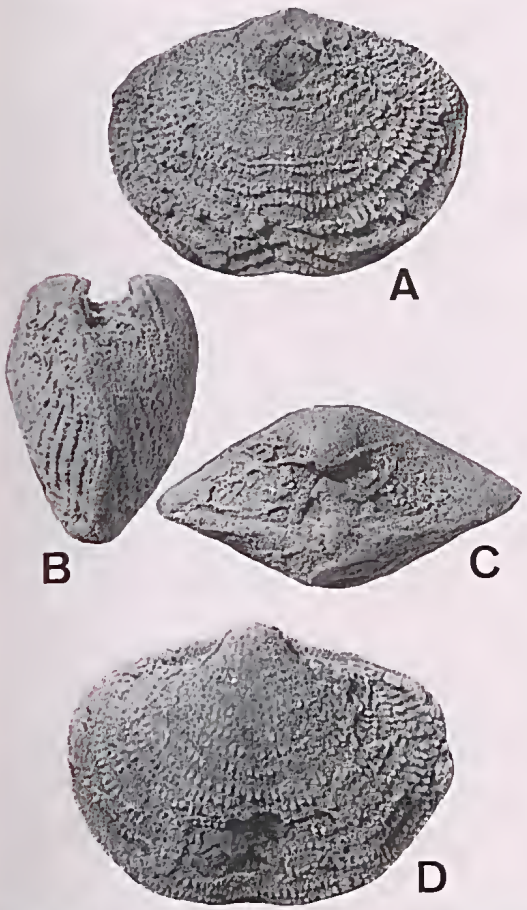

Fig. 15. A–D, *Spirelytha kashirtsevi* sp. nov., CPC 24231, holotype, natural cast of shell in dorsal, profile, posterior and ventral view, × 2.

Discussion. Archbold & Thomas (1984a) noted that this specimen represented a separate species, which is now named because of its distinct biconvex profile, comparable size of both valves and consequent angle of the ventral interarea to the plane of the dorsal valve.

Most literature on *Spirelytha* was reviewed by Archbold & Thomas (1984a) but it is noted herein that Kashirtsev (1955) recorded the genus from north-eastern Russia. Since the 1984 review, two Western Australian species have been recorded from north-eastern Russia, namely *Spirelytha fredericksi* by Klets (1987) and *S. miloradovichi* by Abramov & Grigoryeva (1988).

Zone. Fusispirifer cundlegoensis Zone. Late Baigendzhinian.

ACKNOWLEDGEMENTS

Dr S. K. Skwarko (Geological Survey of Western Australia), Dr J. M. Dickins (Australian Geological Survey Organisation), Dr A. Ritchie (Australian Museum), Ms G. M. I. Rockett (Department of Geology, University of Western Australia) and Dr K. McNamara (Western Australian Museum) are all thanked for the loan of specimens and for providing locality details. Mrs C. Serpell typed the manuscript. My work on Late Palaeozoic brachiopod faunas of Western Australia is supported by the Australian Research Council (Project A 38930315).

REFERENCES

References are supplementary to those in Parts 1–10 (*Proceedings of the Royal Society of Victoria*, vol. 91: 181; vol. 93: 109; vol. 95: 237; vol.

96: 83; vol. 97: 19; vol. 98: 97; vol. 99: 19; vol. 100: 21; vol. 102: 1; vol. 103: 55).

AFANASYEVA, G. A., 1988. Brakhiopody otryada Chonetida. *Trudy paleontologicheskogo instituta, Akademiya nauk SSSR* 228: 1–123.

ARCHBOLD, N. W., 1981d. Studies on Western Australian Permian brachiopods 2. The family Rugosochonetidae Muir-Wood 1962. *Proceedings of the Royal Society of Victoria* 93: 109–128.

ARCHBOLD, N. W., 1984a. Western Australian occurrences of the Permian brachiopod genus *Retimarginifera*. *Alcheringa* 8: 113–122.

ARCHBOLD, N. W., 1988a. Studies on Western Australian Permian brachiopods 8. The Late Permian brachiopod fauna of the Kirkby Range Member, Canning Basin. *Proceedings of the Royal Society of Victoria* 100: 21–32.

ARCHBOLD, N. W., 1990. Studies on Western Australian Permian brachiopods 9. The Sterlitamakian brachiopod fauna of the Cuneudgerie Sandstone, Canning Basin. *Proceedings of the Royal Society of Victoria* 102: 1–13.

ARCHBOLD, N. W., in press. A zonation of the Permian brachiopod faunas of Western Australia. In *Gondwana 8: Assembly, Evolution and Dispersal*, R. H. Findley, M. R. Banks, J. J. Veevers & R. Unrug, eds, A. A. Balkema, Rotterdam.

ARCHBOLD, N. W. & BIRD, P. R., 1989. Permian Brachiopoda from near Kasliu Village, West Timor. *Alcheringa* 13: 103–123.

ARCHBOLD, N. W. & THOMAS, G. A., 1985a. Permian Spiriferellinae (Brachiopoda) from Western Australia. *Alcheringa* 9: 35–48.

ARCHBOLD, N. W. & THOMAS, G. A., 1986a. Permian Ingelarellidae (Brachiopoda) from Western Australia and Argentina. *Journal of Paleontology* 60: 581–605.

BENEDIKTOVA, R. N., 1956. Spiriferidy Ostrogskoi svity Kuzbassa. In *Materialy vtorogo soveshcheniya po stratigrafii uglenosnykh otlozhenii* (*Voprosy geologii Kuzbassa* 1), Ugletekhizdat, Moscow, 169–182.

BRANISA, L., 1965. Los fosiles guias de Bolivia. 1. Paleozoico. *Servicio Geologico de Bolivia, Boletin* 6: 1–250.

CAMPBELL, K. S. W., 1959. The *Martiniopsis*-like spiriferids of the Queensland Permian. *Palaeontology* 1: 333–350.

COOPER, G. A. & GRANT, R. E., 1976. Permian brachiopods of West Texas, 4. *Smithsonian Contributions to Paleobiology* 21: 1923–2607.

DING Y.-J., XIA G.-Y., DUAN C.-H., LI W.-G., LIU X.-L. & LIANG Z.-F., 1985. Study on the Early Permian stratigraphy and fauna in Zhesi district, Nei Mongol Zizhiqu (Inner Mongolia). *Bulletin of the Tianjin Institute of Geology and Mineral Resources* 10: 1–241.

EINOR, O. L., 1946. Brakhiopody nizhnego karbona i nizhnei permi zapadnogo Taimyra. *Trudy gorno-geologischeskogo upravleniya* 26: 1–93.

ETHERIDGE, R., Jnr, 1889. Remarks on fossils of Permo-Carboniferous age, from north-western Australia, in the Maeleay Museum. *Proceedings of the Linnean Society of New South Wales* 4 (2): 198–214.

FREDERICKS, G. N., 1934. Fauna permskikh otlozhenii Poluostrova Kanina. *Trudy arkticheskogo instituta* 13: 5–42.

GRANT, R. E., 1966. Spine arrangement and life habits of the productoid brachiopod *Waagenoconcha*. *Journal of Paleontology* 40: 1063–1069.

GRUNT, T. A., SARYCHEVA, T. G. & SOKOLSKAYA, A. N., 1974. Permskaya sistema. Brakhiopody. In *Atlas iskopaemoi fauny Armyanskoi SSR*, V. T. Akopyana, ed., Akademiya nauk Armyanskoi SSR, Yerevan, 127–148.

KALASHNIKOV, N. V., 1986. Brakhiopody. In *Atlas kharakternykh kompleksov permskoi fauny i flory Urala i Russkoi platformy. Trudy vsesoyuznyi ordena Lenina nauchno-issledovatel'skii geologicheskii Institut im. A. P. Karpinskogo* 331: 29–30, 90–94, 231–250.

KASHIK, D. S., 1990. Opornyi razrez permi Omolonskogo Massiva. *Trudy mezhvedomstvennyi stratigraficheskii komitet SSSR* 21: 1–198.

KASHIRTSEV, A. S., 1955. Materialy po stratigrafii i paleontologii verkhnepaleozoiskikh otlozhenii yugo-zapadnogo Verkhoyanya (verkhov'ya basseina r. Tumary). *Trudy Yakutskogo filiala akademiya nauk SSSR* 2: 63–87.

LEE L., GU F. & LI W.-G., 1984. Early Permian productids from Xi Ujimqin Qi, Nei Monggol Autonomous. *Professional Papers of Stratigraphy and Palaeontology* 11: 71–82.

LIKHAREV, B. K., 1931. Materialy k poznaniyu fauny verkhne-permskikh otlozhenii severnogo Kraya. *Trudy glavnogo geologo-razvedochnogo upravleniya VSN Kh. SSSR 71: 1–42.*

RUZHENTSEV, V. E. & SARYCHEVA, T. G., 1965. Razvitie i smena morskikh organizmov na rubeshe paleozoya i mezozoya. *Trudy paleontologicheskogo instituta, Akademiya nauk SSSR* 108: 1–431.

SAMTLEBEN, C., 1971. Zur Kenntnis der Produktiden und Spiriferiden des bolivianischen Unterperms. *Beihefte zum Geologischen Jahrbuch* 111: 1–163.

SARYCHEVA, T. G., 1984. Produktidy roda *Waagenoconcha* Chao v karbone i permi Sibiri i Arktiki. *Trudy paleontologicheskogo instituta, Akademiya nauk SSSR* 199: 120–135.

SOLOMINA, R. V., 1960. Nekotorye permskie brakhiopody Pai-khoya. *Sbornik statei po paleontologii i biostratigrafii* 19: 25–73.

STEPANOV, D. L., 1936. Materialy k poznaniyu brakhiopodovoi fauny verkhnego paleozoya Shpitzbergena. *Uchenye zapiski Leningradskii gosudarstvennyi universitet, Seriya geologo-pochvenno-geograficheskaya* 2: 114–128.

STEPANOV, D. L., KULIKOV, M. V. & SULTANAEV, A. A., 1975. Stratigrafiya i brakhiopody verkhnepermskikh otlozhenii Poluostrova Kanin. *Vest*

nik Leningradskogo universiteta 6: 51–65.

TAZAWA, J.-I., 1974. *Waagenoconcha* (Brachiopoda) from the Permian of the southern Kitakami Mountains, northeast Japan. *Journal of the Faculty of Science Hokkaido University, Series IV, Geology and Mineralogy* 16: 121–143.

TSCHERNYSCHEW, T. N., 1904. Brachiopoda. *Productus humboldtii* d'Orbigny, 1842. *Palaeontologia Universalis*, Centuria 1: 31–31a.

WATERHOUSE, J. B., 1968. The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica Abteilung A* 129: 1–94.

WATERHOUSE, J. B. 1969a. World correlations of New Zealand Permian stages. *New Zealand Journal of Geology and Geophysics* 12: 713–737.

WATERHOUSE, J. B., 1983a. New Permian invertebrate genera from the east Australian segment of Gondwana. *Bulletin of the Indian Geologists' Association* 16: 153–158.

WATERHOUSE, J. B., 1983b. Permian brachiopods from Pija Member, Senja Formation, in Manang district of Nepal, with new brachiopod genera and species from other regions. *Bulletin of the Indian Geologists' Association* 16: 111–151.

WIMAN, C., 1914. Über die Karbonbrachiopoden Spitzbergens und Beeren Eilands. *Nova Acta Regiae Societatis Scientiarum Upsaliensis, Seriei Quartae* 3: 1–91.

YANISHEVSKIY, M. E., 1935. Opisanie fauny iz osnovaniya uglenosnoi tolshi Kuznetskogo Basseina. *Uchenye zapiski Leningradskogo gosudarstvennogo universiteta, Seriya geologo-pochvennykh-geograficheskaya* 1: 53–76.

ZAVODOVSKIY, V. M., 1960c. Novye vidy permskikh linoproduktid Severo-Vostoka SSSR. In *Novye vidy drevnikh rastenii i bespozvonochnykh SSSR, Chast' I*, B. P. Markovskii, ed., Gosudarstvennoe nauchno-tekhnicheskoe izdatel'stvo, Moscow, 320–328, 578–585.